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PROCEEDINGS

OF THE

CONFERENCE ON THE SPIKE DISEASE OF SANDAL

Held in Bangalore from 4th to 7th Oct., 1917

WITH APPENDIX AND TWO MAPS

BANGALORE:
PRINTED AT THE GOVERNMENT PRESS
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FOREWORD.

THE First Conference on Spike Disease of Sandal convened on the initiative of the Government of His Highness the Maharaja of Mysore, met in Bangalore on the 4th October, 1917. The following Report of the Proceedings has been prepared by me with the assistance of Mr. K. Kunhi Kannan, Senior Assistant Entomologist, Mysore, Department of Agriculture, who acted as Secretary of the Conference. The draft proceedings were circulated to the members for correction before being sent to the press.

LESLIE C. COLEMAN,
Chairman of the Conference.

March 1918.

PROCEEDINGS OF THE CONFERENCE ON SPIKE DISEASE OF SANDAL HELD IN THE OFFICE OF THE DIRECTOR OF AGRICULTURE IN MYSORE, BANGALORE FROM 4TH TO THE 7TH OCTOBER, 1917.

List of Members and Visitors.

Dr. Leslie C. Coleman, m.a., ph.d., *Director of Agriculture in Mysore, Bangalore.*

Mr. R. S. Hole, *Forest Botanist, Dehra Dun.*

Mr. P. M. Lushington, *Conservator of Forests, Southern Circle.*

Mr. C. D. McCarthy, *Conservator of Forests, Western Circle.*

Mr. M. G. Rama Rao, *Conservator of Forests, Mysore State.*

Mr. H. Tireman, *Deputy Conservator of Forests, Coorg.*

Rao Sahib M. Rama Rao, *Special Forest Officer, Mysore State.*

Mr. T. N. Hearsey, *Special Spike Investigation Officer, Madras Forest Department.*

Mr. B. V. Ramiengar, *Deputy Conservator of Forests, Mysore State.*

Mr. P. S. Govinda Rao, *District Forest Officer, Mysore.*

Mr. H. S. Narayana Rao, *Special Working Plans Officer, Mysore.*

Mr. L. P. Mascarenhas, *District Forest Officer, Mysore.*

Mr. H. V. Krishnayya, *Chemist, Agricultural and Geological Departments, Mysore State.*

Mr. K. Kunhi Kannan, *Senior Assistant Entomologist, Agricultural Department, Mysore State.*

Mr. M. J. Narasimhan, *Assistant Mycologist, Agricultural Department, Mysore State.*

Mr. Sankar Rao Badami, *Assistant Chemist, Agricultural Department, Mysore State.*

Visitors.

Mr. S. Srinivasalu Naidu, Rao Bahadur, *Extra Deputy Conservator of Forests, Central Provinces.*

Mr. H. Srinivasa Rao, *Retired District Forest Officer, Mysore.*

ORIGIN OF THE CONFERENCE.

The Conference was called together at the instance of the Government of His Highness the Maharaja of Mysore. The Government of India, the Government of Madras and the Government of Coorg, on being approached, expressed their willingness to send representatives. The object of the Conference was to bring together all the information at present available on the disease and to formulate a comprehensive plan of investigation for the future.

AGENDA OF THE CONFERENCE.

1. The spread of Spike Disease. Its present extent and future prospects. The preparation of an accurate map of infestation to be brought up-to-date every year.
2. The losses from Spike Disease and how they can best be estimated.
3. The influence of external conditions upon the prevalence and spread of Spike Disease.
4. Spike Disease of other plants and their relation to Spike Disease of sandal.
5. Theories as to the cause of Spike Disease of sandal and their bearing on practical combative measures.
6. Combative measures undertaken in the past and the results obtained.
7. Suggestions *re* combatting the disease in the light of our present knowledge.
8. Organization of Spike Disease investigation for the future. The question of publishing a combined annual report giving the results of work done during the previous year may be considered.

LIST OF NOTES AND PAPERS READ BEFORE THE CONFERENCE.

1. The Cause of Spike Disease on Sandal, by Mr. R. S. Hole.

2. Experiments in Connection with Spike Disease of Sandal, by Mr. T. N. Hearsey.

3. Note on Spike Disease, by Mr. P. M. Lushington.

4. Note on the History of Sandal Spike in Mysore, by Mr. M. G. Rama Rao.

5. Note on Experiments to Test the Effect of Removing Lantana on the Incidence of Spike Attack, by Mr. H. Tireman.

6. Note on Spike Disease, by Mr. C. D. McCarthy.

7. Field Investigation of Spike Disease in Sandal on the Kollimalai Hills, by Mr. M. Rama Rao, Rao Sahib.

PROCEEDINGS OF THE CONFERENCE.

The Conference opened at 12 noon on the 4th October 1917 in the office of the Director of Agriculture in Mysore, Bangalore. Dr. Coleman presided. In his opening remarks he said that the Conference had been called together with the object of bringing about a greater degree of co-ordination in the work which is being done on sandal, more especially with reference to Spike Disease. A large amount of information with regard to sandal, in its healthy as well as in its diseased condition, had been gathered by Forest Officers who had worked in sandal areas, but much of this had never been published and so was not available to investigators of the disease. Taking into consideration the seriousness of the disease (the present losses have been estimated at Rs. 6 lakhs a year) and the increasing value of sandal, he thought that no information in any way connected with the growth of the tree or the appearance and spread of the disease could be looked upon as unimportant. The views of various workers with regard to the disease were likely to be largely influenced by the way in which they had approached the subject. The Forest Officer was likely to base his conclusions chiefly on field observations, the Mycologist on microscopic study and infection experiments, the Chemist on chemical analyses. It was, he believed, very unlikely that they should ever be able to clear up all the points connected with this baffling disease and arrive at a satisfactory method of controlling it, unless they utilized every agency which they could command in its investigation. The work of the Conference should therefore be to consider all information that is at present available and to map out a programme of work for the future which would embrace all aspects of the subject and would at the same time ensure co-ordinated

effort towards the investigation of the disease and in the devising of practical and efficient measures of control.

Dr. Coleman regretted that there had not been sufficient time to consult the members of the Conference with regard to the various subjects which could profitably be discussed. He had, however, prepared an agenda paper which, he believed, covered the field in a fairly satisfactory manner. A number of the members had agreed to submit notes and his own bulletin on the subject was in their hands. These would also be discussed in the Conference. In conclusion, he felt sure that, although it was certain that very divergent views would be expressed on the subject, an effort would be made to reach definite conclusions which would serve to guide them in future work.

Copies of the agenda paper were distributed among the members with the following note :—

The provisional agenda paper is submitted for the approval of the Conference. It is not to be considered as complete and any member of the Conference desiring to bring up other subjects for discussion will, of course, do so. Our object should, I take it, be to discuss the subject in all its aspects as far as our present knowledge permits us to do so.

The Conference considered that before taking up the various items of the agenda it was desirable to have all available information placed before them. It was therefore decided to have the notes already prepared, read.

Mr. Hole's note on the cause of Spike was then read and arrangements were made for having copies prepared for circulation to the members on the following day. The note will be found in the appendix. This was followed by a note by Mr. Hearsey detailing the results of experiments conducted by him on the connection between insect attack and Spike Disease. As the paper was a very long one going into considerable detail with regard to individual experiments, Mr. Lushington agreed to extract the main points for inclusion in the Proceedings of the Conference.

The Conference then adjourned to inspect experiments on Spike Disease which were being carried out by the Agricultural Department. These consisted of graft infection experiments on sandal, *Zizyphus oenoplia*, *Vinca rosea* and *Stachytarpheta indica* together with experiments to ascertain the rate of carbon assimilation in sandal leaves, spiked and healthy.

The second session of the Conference opened on the 5th October at 12 noon. After an examination of specimens collected by Mr. Hearsey and the staff of the Mysore

Department of Agriculture showing spike-like growths on various different plants, the reading of papers was continued. Mr. P. M. Lushington's note was first read. Mr. Lushington remarked that the note had not been prepared for publication and was largely based on results obtained by Mr. Hearsey which had been described in that officer's second report. He proposed to revise his note somewhat for publication in the Proceedings. The note as revised will be found in the appendix.

This was followed by a note by Mr. M. G. Rama Rao detailing the his ory of Spike Disease in Mysore. The note was accompanied by a map giving the latest information *re* the areas infested in the State. The note is given in the appendix.

Rao Sahib M. Rama Rao agreed to prepare a note giving the essential points of his investigations on the disease for publication in the Proceedings. He pointed out that his note would not contain matter upon which discussion would arise as it was simply an account of observations made.

A note by Mr. Tireman on the experiments to test the effect of removing lantana on the incidence of Spike attack was submitted but was not read as Mr. Tireman was indisposed.

The Conference then took up the discussion of the notes.

Mr. Hole's note on disease in sandal evoked lively discussion. Mr. Hole's theory bases the cause of the disease on an unbalanced circulation of sap, which could result from a number of external factors, such as lantana, fire and lack of soil moisture. Dr. Coleman pointed out that an unbalanced circulation could be looked upon only as the immediate cause and not the primary cause of the disease.

When questioned as to the grounds upon which he based his theory that a reduction in water supply resulted in a greater reduction in the translocation stream rather than in transpiration and carbon assimilation, Mr. Hole stated that this view had been borne out by experiments recently conducted in America and he believed the theory explained all the phenomena connected with the disease in a simpler manner than any other theory that had been as yet advanced.

A number of the members present among them being, Mr. M. G. Rama Rao, Mr. B. V. Ramiengar, Mr. Lushington and Mr. McCarthy, pointed out that as Mr. Hole's observations inthe field had been confined to Coorg where the conditions were in many respects peculiar, it was unsafe to utilize such observations in the formulation of a general theory for

the disease. With regard to both lantana and fire, large areas could be found in Mysore and Madras where both had been active through many years and yet no Spike had appeared. Mr. McCarthy also noted that even in Coorg the appearance of lantana had long antedated the appearance of Spike. Mr. Hole in reply pointed out that he had not confined his attention to these two factors alone. While he believed that they could be held accountable for the disease in many cases, any factor which was likely to reduce the water supply to the trees was likely to produce similar results.

With regard to the appearance of spike-like growth on trees badly burnt as noted by Mr. Hole, both Mr. H. S. Narayana Rao and Rao Sahib Rama Rao considered that this should be looked upon as a temporary reaction and that later, the growth would once more become normal. They had both seen examples of this. With reference to this objection, Mr. Hole pointed out that his observations referred to typical Spike and not to " spike-like growth." Dr. Coleman considered that sufficient evidence had not been adduced to warrant a belief that Spike could be produced by fire. We have not sufficient knowledge of the history of individual trees to state with any degree of certainty that trees which may appear to exhibit Spike as a result of fire were not previously attacked. All Mr. Hole's observations had been made in an area where Spike is prevalent; so the possibility of the previous infection of a tree was by no means excluded. That fire might hasten the external appearance of the disease would, he believed, be accepted by all.

In reply to Mr. Lushington's query as to the grounds on which he regarded lantana as an unsatisfactory host for sandal, Mr. Hole stated that his field observations indicated that, although sandal haustoria readily penetrated the roots of lantana, these haustoria appeared to decay more quickly than they do in the case of a good host like *Acacia suma*. He thought that this suggested some deleterious effect on the part of lantana. Dr. Coleman remarked that we have as yet very little knowledge as to the relative value of different host plants. The presence of many dead haustoria was a common feature with practically all host plants. Mr. Narasimhan had found a very large number in the case of *Cassia florida* which was considered a very good host plant. This subject was worthy of investigation.

With regard to the point raised by Mr. Hole that the occurrence of the disease in isolated areas could best be explained by his theory, Dr. Coleman maintained that the

occurrence of isolated areas of disease did not necessarily negative a theory of infection. In many cases where a definite infective organism had been established, isolated areas had been found; but the exact connection between these isolated areas had not yet been worked out. In this connection he cited the case of *Koleroga* of the arecanut, a disease which, while undoubtedly caused by a definite fungus parasite, is found in two widely separated and disconnected areas, Mysore, North and South Canara forming one area and South Malabar and Cochin, the other.

With regard to Mr. Hole's explanation of the results of graft infections carried out by the Mysore Agricultural Department, Dr. Coleman did not see how the small amount of starch which was to be found in the minute spiked scion could produce the results which Mr. Hole described in his paper. In this connection he pointed out that, as a matter of fact, the whole of the starch disappeared from the scion shortly after connection had been formed with the stock and returned only later. He considered the accumulation of starch to be only a symptom and not necessarily even a constant symptom of the disease. Mr. Hole pointed out that the disappearance of starch did not negative the existence of an excess of carbohydrates in solution which might cause a progressive weakening of enzymatic activity. The Conference while on the whole not agreeing with Mr. Hole's theory, considered that experiments on the lines he suggested should be carried out as they were likely to yield valuable information.

Mr. Lushington's and Mr. Hearsey's papers were then taken up for discussion.

In starting the discussion, Dr. Coleman stated that the honey dew secreted by scale insects generally covers the upper surface of the leaves as the insects are usually *on their under side* and thus drop their secretion on the upper surfaces of leaves immediately beneath. There cannot therefore be any clogging of the stomata. Besides, he did not think that clogging of the stomata could produce the sequence of phenomena called 'Spike.' It is true where the attack by scale insects is severe, there may be a reduction of leaves as a result of reduced sap; but even in the worst cases, so far as he was aware, there was not anything like the reduction of leaf which had been observed in Spike. The honey dew may be indirectly responsible for the defoliation of the trees without a preliminary reduction of the leaves. On the honey dew, black fungi (sooty moulds)

grow as a thick film which intercepts the light rays preventing carbon assimilation. As a result of this, the leaves drop off. For this phenomenon the insects are clearly not responsible except indirectly.

As regards the injury to the tissues inflicted by insects, very valuable researches have been carried out in Java on green bug on coffee by Keuchenius. According to him the proboscis reaches the outer margin of the phloem and the ends of the medullary rays on the leaves. These are the two parts which are most affected. The result is that these tissues as well as the surrounding cells even of the cambium and wood, become completely brown and dead. There is a certain amount of plasmolysis in the epidermal and subepidermal cells which are pierced in the process of penetration as well as in the neighbouring cells, but the original turgor is later on restored in these cells. There is an injection of saliva which first takes the form of irregular masses. These later on become sheaths for the proboscis, which remain after the proboscis is withdrawn. The conclusion which Keuchenius reaches from these investigations is that the injury to the plant is a direct result of the sucking action and is not due to any poison injected into the leaf by the insect while feeding.

Mr. Lushington drew attention to insects like the mosquito which injected a specific poison and also pointed out the possibility that the action of the insects which had been found attacking sandal might be different from the insects noted as attacking coffee.

Dr. Coleman.—In the case of the mosquito, what is injected is a definite organism with which the mosquito was previously infected.

Mr. Lushington.—But there is also an irritant which secures a free supply of blood.

Dr. Coleman.—Yes ; but there is no circulatory system in the plants so well developed as in animals and a specific irritant for such a purpose would not be necessary in the case of the former. Moreover, there is no evidence to show that this irritant is in itself infective.

Mr. Lushington.—What about insects like Psylla which produce galls and in the case of indigo produce a crumpling of leaves ?

Dr. Coleman.—There may be such reactions produced by insects but what I wish to point out is that there is, as far as I am aware, no case on record of an insect injecting into the plants a virus which is produced in the insect itself

and which at the same time produces not only a reaction in the plants but also a disease that is capable of transmission from the plant so infected to another plant by means of grafting or inoculation.

Dr. Coleman continuing said that the evidence so far adduced is against any theory of insects as the originators of Spike Disease. But it by no means negatives the possibility of their acting as carriers of infection. It is quite possible that insects may carry the virus from tree to tree.

Mr. McCarthy.—My observations also lead me to believe that insects may act as carriers and from the nature of the spread of infection I think the insects which act in this manner are insects of short flight.

Mr. Lushington said that his observations led him to precisely the opposite conclusions to those reached by Mr. McCarthy.

Dr. Coleman.—There is no doubt that the share of the insects, if any, has to be determined and Mr. Lushington and Mr. Hearsey should continue the interesting line of investigation which they have begun. The Department of Agriculture in Mysore is prepared to co-operate.

The third session of the Conference was held on Saturday the 6th October at 12 noon. Mr. M. G. Rama Rao's note was first taken up. Mr. Tireman enquired with regard to the third type of Spike which Mr. Rama Rao had referred to as the weeping type. Mr. Rama Rao stated that trees showing the characteristics mentioned had been found on the Mysore side of the Cauvery not far from Fraserpet. Trees affected resembled very much weeping willows. Mr. B. V. Ramiengar also stated that he had seen trees of this type. Several of the members stated that they had seen this type of growth in apparently healthy trees and therefore did not consider that it was necessarily to be looked upon as a type of Spike.

Mr. Tireman's paper did not evoke much discussion. It was agreed by all that the results obtained were most interesting and that the work should be continued.

Mr. McCarthy then asked to be allowed to read a short note which he stated he had prepared rather hurriedly. This paper which is printed in the appendix gave the results of his observations on the disease from the time he first discovered it in Coorg. The chief conclusions reached by him were as follows :—

(*a*) the disease probably spreads through the air and not through the underground portions ;

(*b*) insects probably form the chief carriers of the disease;

(*c*) there was, in his opinion, a close connection between Spike Disease of sandal and similar diseases of other plants, notably of *Zizyphus oenoplia*; and

(*d*) the most effective way of preventing its spread was by removing sandal and *Zizyphus* from a belt in front of the line of spread.

After a short discussion the Conference turned to a consideration of the agenda paper. The discussions of the various notes read had already touched upon many of the subjects in the agenda so that it was unnecessary to consider them at great length.

1. *The spread of Spike Disease. Its present extent and future prospects. The preparation of an accurate map of infestation to be brought up-to-date every year.*

The question of the preparation of an accurate map showing infestation was first taken up and after some discussion the following resolution was adopted :—

Resolved that an accurate map showing infestation should be prepared in the Office of the Director of Agriculture, Mysore, on information furnished by the various Forest Departments concerned. This map should be on a scale of 12 miles to the inch. The map should be brought up-to-date and republished every year, copies being made available to the Forest Departments.

The Conference understands that in the Madras Presidency and Coorg, the present staff will be able to furnish the information necessary for the map. The Conservator of Forests in Mysore stated that a special sandal survey had been sanctioned by the Mysore Government and that infested areas would be taken up first. The necessary information should be therefore available within a year.

The question of the manner of spread of the disease was then discussed. The interesting fact was noted that in Mysore State the spread has taken place much more rapidly eastward and southward than northward. The infested areas in Madras Presidency are so scattered that no definite statement with regard to the direction of spread can at present be made. No reason can at present be ascribed, for the difference in rapidity of spread in different directions in Mysore and the subject is worthy of investigation. The suggestion was made that some connection might exist between the direction of spread and the direction of the prevailing winds. The survey which is to be carried out by the Mysore Forest Department should throw light

on the question of spread in Mysore. Messrs. McCarthy and Hole suggested that the distribution of rainfall might be partly responsible for the direction of spread, the disease spreading more rapidly in areas of lighter rainfall.

The question of the discontinuity of the disease was also considered. It was pointed out that in Madras Presidency the disease had appeared in distinct areas far apart from each other (the greatest distance between such areas being about 100 miles) and a similar discontinuity was to be observed in Mysore. The opinion of the Conference, however, was that in many of these cases absolute proof of discontinuity had not been furnished as the tracts between had not been thoroughly inspected. The following resolution was passed :—

Resolved that this Conference considers that the question of investigating the possibility of connections between apparently isolated infected areas is very important and recommends that where it is considered feasible to take up this investigation, a special trained staff should be set apart for the work.

2. *The losses from Spike Disease and how they can best be estimated.*

The discussions on this subject elicited the general opinion that it would be very difficult to make more than a very rough estimate of the losses which have been caused by Spike. The conclusions arrived at may be summed up as follows :—

In the opinion of the Conference the estimate of losses from Spike Disease framed by Dr. Coleman (*vide*, Spike Disease of Sandal, Mycological Series Bulletin No. 3, Department of Agriculture, Mysore State, page 8) may be taken as a rough guide, erring on the conservative side. The Conference considers that a more accurate estimate of the losses is at present impossible. An essential towards the framing of such an estimate is the possession of accurate working plans for sandal areas which the Conference considers should be prepared as rapidly as possible.

3. *The influence of external conditions upon the prevalence and spread of Spike Disease.*

As this subject had been pretty fully discussed in connection with Mr. Hole's note, it was not considered necessary to devote more time to it. The conclusions reached were as follows :—

The Conference considers that experiments on the influence of external factors should be carried out, as far as

possible on the lines suggested by Mr. Hole in his note. As Mr. Hole suggests these experiments should be carried out in areas which are at present uninfected. It is understood that Mr. Tireman is prepared to carry out such experiments in Coorg and Mr. M. G. Rama Rao, Conservator of Forests expressed his willingness to conduct similar experiments in Mysore.

4. *Spike Disease of other plants and their relation to Spike Disease of sandal.*

Mr. Lushington and Mr. Hearsey had, in their notes, given the names of over thirty plants which show disease symptoms similar to those of Spike Disease of sandal. It was pointed out however, that in all probability, a number of these diseases would be found to be due to insect or fungus attack. The Conference considered that the indiscriminate use of the term Spike Disease for all these diseases is likely to lead to confusion. The following resolutions on this subject were accepted by the Conference :—

Resolved that this Conference considers that in order to avoid confusion, the term Spike Disease should be restricted to the disease of sandal characterised by the external features first described by Mr. McCarthy and given in detail in Dr. Coleman's bulletin.

Resolved that extensive observations should be made on plants other than sandal which show symptoms similar to Spike Disease with special reference to possible relationships which these symptoms may have with the disease of sandal.

6. *Combative measures undertaken in the past and results obtained.*

The only combative measures attempted on a practical scale up to the present have been

(*a*) the uprootal of diseased trees in infected areas ; and

(*b*) the isolation of infected areas by clearing all sandal and *Zizyphus* ahead of the line of infection.

With regard to (*a*) the Conference was unanimously of the opinion that the results had been entirely negative. With regard to (*b*) the opinions of members differed. In Mysore where only sandal had been removed and in the Javalagiri Reserve (North Salem) no effect could be observed. In Mysore the work was continued from 1903 to 1905. In the Javalagiris it was commenced in 1913. Here as Mr. McCarthy pointed out, the measures had not been properly carried out in the beginning but Mr. Lushington stated that they had been regularly and properly carried out since 1915. In

Coorg, the work was commenced in 1901 and has been continued up to the present. No disease had appeared north of the isolation line till August 1916 when two trees about a mile north of the line were attacked. At about the same time in 1916, an individual tree was attacked three miles west of the infected area on the other side on a hill range which was devoid of sandal. Mr. Lushington states that he proposed to carry out an isolation experiment on a newly infected area in the Javadis, West Vellore.

5. *Theories as to the cause of Spike disease of sandal and their bearing on practical combative measures.*

7. *Suggestions* re *combating the disease in the light of our present knowledge.*

These two subjects were discussed together as they were considered by the Conference to be intimately connected.

The discussion centered about two main points :—

(*a*) the possibility of controlling the disease by the elimination of unfavourable external factors ; and

(*b*) the possibility of checking the spread of the disease by cutting out sandal and other plants susceptible to diseases similar to Spike in front of the line of advance.

With regard to (*a*) while there was a marked difference of opinion as to the influence of external factors on the appearance and spread of Spike Disease, the Conference were generally of the opinion that it would be sound practice to remove conditions which were clearly unfavourable to the vigorous growth of sandal. Thus, protection from fire was considered as highly important. With regard to lantana, it was also generally felt that its removal would be beneficial to sandal growth and the question of lantana removal in sandal area, more especially in those in which Spike Disease has appeared, was considered to be one which should engage the serious and immediate attention of the Forest Departments concerned. The interesting results obtained by Mr. Tireman in Coorg and given in his note gave additional weight to this opinion.

With regard to (*b*) it was the opinion of the Conference that while the evidence available was not such as to warrant the Conference recommending the general adoption of this measure, it was nevertheless worthy of an extended trial.

The results of the discussion were summed up in the following resolution :—

Resolved that this Conference considers that, in the light of our present knowledge, no practical combative

measures can be recommended for general acceptance. The Conference recognizes, however, the value of the work being done in Coorg in connection with the removal of lantana and the establishment of isolation lines and considers that this work should be continued. The Conference also considers that all other possible predisposing factors, such as fire and damage or removal of suitable host plants, should be eliminated.

8. *Organization of Spike Disease investigation for the future.*

The following programme of work was mapped out for the future. This programme included lines of investigation along which work has already been commenced.

(i) The Conference understands that Mr. Hole is investigating the question of Spike Disease from the standpoint of water supply as affected by various external factors. Experiments on the lines suggested by him will be carried out by Mr. Tireman in Coorg and by the Conservator of Forests in Mysore.

(ii) Isolation experiments on the lines suggested by Mr. McCarthy will be continued in Coorg and Mysore and will be started in a new area in the Javadis by Mr. Lushington.

(iii) The experiments of the Mysore Department of Agriculture as detailed in Dr. Coleman's bulletin will be continued and extended. Work on the nutrition of sandal with special reference to its root parasitism will form an important subject for investigation by the Biochemist, who will shortly be appointed to assist Dr. Coleman.

(iv) The experiments conducted by Messrs. Lushington and Hearsey on the relationship of insects to the disease will be continued and the Mysore Department of Agriculture will co-operate. It is understood that Mr. Beeson, Forest Entomologist, Dehra Dun, is also prepared to co-operate in this investigation.

The Conference wish to lay special stress upon the following additional lines of investigations which should be taken up at once and work upon which should be pushed ahead as rapidly as possible :—

(v) A thorough investigation of the course of the disease in the field. This should be taken up in as many different localities, and under as many different conditions as possible.

(vi) Investigation of the possibility of propagating the disease through seed from trees, portions of which show typical Spike. Work in this connection has already been

commenced by the Mysore Department of Agriculture and by Messrs. Lushington and Hearsey.

(vii) Investigation of the possibility of producing disease-resistant strains of sandal. This should be done by testing seedlings from

(*a*) healthy trees which have survived in heavily spiked areas; and

(*b*) healthy trees from areas where Spike has never appeared.

The immunity of seedlings should be tested in two ways, *viz.*—

(*a*) by graft infection experiments; and

(*b*) by growth in selected areas where the disease is particularly virulent.

(viii) Investigation on areas which have been badly infected to ascertain if the disease ever entirely disappears from such areas.

(ix) Extensive observations should be made on plants other than sandal which show symptoms similar to sandal Spike with special reference to their relationship to sandal Spike. *Zizyphus oenoplia* should be chosen for special investigation.

The question of making available the results of observations and investigations by different officers was discussed and it was considered that these should be brought up for discussion at a meeting of the Conference which should be held in October 1918. They should then be published for general information in a report of the Proceedings of the present Conference, the publication being placed in the hands of the Director of Agriculture, Mysore.

In bringing the Proceedings of the Conference to a close, Dr. Coleman congratulated the authors of papers received before the Conference on their valuable contributions and those who took part in the discussion. He believed that members realized much more fully than they had before, the complexity of the problems that have to be investigated and the many sciences that have to contribute to their solution. He considered that many field observations which almost every Forest Officer had given for the benefit of the Conference were of the utmost value more especially as Forest Officers had unique opportunities for field studies. He hoped that Forest Officers present had also become interested in the progress of work in the laboratory. There was nothing like a free and frank discussion, to present the problems in their true perspective. As regards the discussion it had been

most vigorous. He trusted the members realized the value of this criticism as bringing to notice points of view or observations which may not always occur to the man who keeps to one field of enquiry in regard to a disease which has so many aspects.

In conclusion, he hoped to be able to welcome the members again in his office next year and he trusted that there would at that time be even more valuable criticisms from every one of the members.

LESLIE C. COLEMAN,
Director of Agriculture in Mysore.

APPENDIX.

Papers read at the Conference on Spike Disease.

CAUSE OF SPIKE DISEASE IN SANDAL (*SANTALUM ALBUM*).

By R. S. Hole, Forest Botanist, Dehra Dun.

Procedure followed in study of Spike.

1. When investigating an unknown disease of a forest tree the following appears to be the best general procedure :—

(*a*) to study as extensively as possible the conditions under which the disease occurs in the forest;

(*b*) to formulate a theory based on this study as to the cause of the disease which is in accordance with the facts ascertained under (*a*);

(*c*) to obtain by actual experiment the proof, or the reverse, of the theory advanced.

The writer has now studied Spike in the forests of Coorg during two tours at different seasons of the year and has also tested the effect of various factors on the growth of sandal in the Experimental Garden at Dehra Dun. He accordingly now ventures to put forward a theory as detailed below which appears to be in thorough accordance with the facts hitherto ascertained, to ask for a patient consideration of this theory and to request the co-operation of Forest Officers in the sandal areas in obtaining the experimental proof, or otherwise, of this theory.

Balanced circulation of sap.

2. The primary cause of Spike is believed to be an *unbalanced circulation of sap.*

In the case of a tree in which sufficient water (crude sap) is ascending the stem to provide for (*a*) the manufacture of carbohydrates and (*b*) the removal of the latter in the form of soluble sugars (elaborated sap) and for their utilization in the processes of growth, the tree is healthy and the sap circulation may be said to be *balanced.*

Suspended sap circulation.

In the case of a tree in which the water supply is insufficient to provide for transpiration and carbohydrate assimilation, if the circulation cannot be sufficiently stopped by shedding the leaves or by other protective devices, the tree must either die or suffer from the death of the twigs and leaves by drought, thus becoming more or less " stag-headed."

Unbalanced sap circulation.

In this case the sap circulation, temporarily at any rate, is practically suspended. Finally, if the water supply is gradually reduced below that which is required for a balanced circulation, the sap circulation becomes *unbalanced* and an accumulation of starch in the leaves and twigs will result, thus gradually cutting off the food supply necessary for the health of the roots. If this last condition is sufficiently prolonged, it is believed that it will cause the condition known as Spike.

Why sandal and *Zizyphus oenoplia* are especially liable to Spike.

3. The majority of trees do not appear to suffer from this last condition to any great extent and the slight accumulations of starch which occur are usually dispersed in the so-called " rest-periods " after which normal growth again sets in. The sandal tree and *Zizyphus oenoplia,*

however, appear to be especially liable to this condition, apparently for the following reasons :—

(*a*) Both species are extremely tenacious of life and are capable of containing carbohydrate assimilation and slow growth under a condition of water supply which in other species would induce death or "stag-head."

(*b*) Both species possess a thick fleshy cortex which usually contains a considerable amount of moisture and the latter often suffices to support for a considerable time, the localized growth of twigs and the manufacture of carbohydrates even when the main system of sap circulation has been stopped. This can frequently be seen in the case of burnt trees in which the cortex, cambium and outer wood have been completely burnt at the base and in which leafy twigs have subsequently been produced from the still living cortex above. Such twigs are frequently found to be spiked.

(*c*) Both species possess a remarkably strong and tenacious power of apical growth and under a gradually decreasing water supply, the lower lateral twigs are found to die off while the tips of the long branches still remain vigorous. Probably, owing partly to the smaller vigour of the laterals and to the fact that they are less well-supplied with water, they are frequently found to suffer more from fire, suppression and insect attacks in both species than are the ends of the stem, and branches. In both species, therefore, under certain unfavourable conditions of growth, we commonly find a continually increasing length of conducting tissue, which must be constantly renewed by a well-nourished cambium if good sap circulation is to be secured, without a proportionate increase in the area of the carbohydrate-producing green leaves and in the total amount of elaborated food necessary for the nourishment of the cambium. This results in an abnormally great length of poorly nourished cambium and slowly conducting tissues. A suddenly increased demand for water in such a poorly developed crown, such as would follow the removal of overhead or lateral shade, cannot quickly be met by the development of new rapidly-conducting tissues for which a well-nourished cambium with a plentiful supply of water and available food is necessary. The water supply for the crown is consequently liable to be less than that required for a balanced circulation and a condition of Spike, " stag-head " or death is likely to ensue.

There is no doubt that, on the whole, the characteristics noted above are advantageous to the species in the struggle for existence. Both sandal and *Zizyphus oenoplia* are notoriously difficult to kill by mutilation while the strong power of apical growth and especially the capacity to continue slow growth when other species are obliged to suspend their growth, give them a great advantage over other competing plants.

It is only under certain unfavourable circumstances that these characteristics seem liable to produce the pathological condition known as Spike.

Factors producing Spike.

4. From all the diseased plants hitherto examined by the writer of *Zizyphus oenoplia* it appears that the unbalanced sap circulation resulting in Spike has been in every case caused by *fire*. In numerous cases of spiked sandal which have been examined, this condition appears to have been brought about by the following four factors :—

(*a*) *Fire*:—Fire damages the trees by killing the delicate aerial twigs and superficial rootlets as well as by more or less drying and damaging the fleshy cortex and cambium of the thicker superficial roots, aerial branches and stem. If sufficiently severe, fire kills the trees outright.

In cases where fire damages chiefly the twigs and branches, *i.e.*, the

upper portions of the tree, the result is usually a " stag-headed " condition and not Spike. In such cases, the water supply in the tissues of the stem combined with that sent up by the uninjured roots, is sufficient for the healthy growth and nourishment of the comparatively short length of cambium and conducting tissues and for the vigorous development of the new adventitious shoots developed below the damaged portion of the crown. In such cases, therefore, there is no unbalanced circulation.

In other cases in which fire damages chiefly the roots and lower portions of the stem and branches, Spike seems especially liable to result even when the damage is apparently not very severe. In such cases, the lower lateral twigs are usually found to have been killed while the apices of the stem and long branches are comparatively healthy. Here, therefore, there is obviously a great length of cambium and conducting tissue, parts of which also have been more or less dried and damaged, or checked in growth by the fire.

The rate of upward flow of water also tends to be diminished by damage to the roots of sandal and of its hosts and by the reduced sucking force in the leaves owing to the destruction of the lateral branches and twigs. The amount of water reaching the terminal twigs, therefore, in a unit of time is reduced, less water will be available for the translocation of the carbohydrates, while the latter is also checked by the more or less severely damaged cortex in the lower portions of the branches and stem. Under this condition of unbalanced circulation, according to the theory now advanced, starch would tend to accumulate leading sooner or later to Spike.

In cases of severe fire, damage not sufficient to cause death, but in which the whole tree has been more or less completely burnt, the water ascending in the inner comparatively uninjured wood together with that locally available in the tissues is sometimes sufficient for the development of dormant and adventitious buds, but the translocation of carbohydrates appears to be too slow to allow of a balanced circulation either on account of a deficiency of water or the severe local burning of the cortex and cambium below. In such cases Spike and not a " stag-headed " condition appears to be the result.

(*b*) *Death or damage of hosts*:—The girdling, uprooting or other damage to hosts may reduce the water supply to that which is only sufficient for an unbalanced circulation, while being insufficient to cause death or " stag-head."

(*c*) *Partial suppression by lantana or other growth*:—This frequently appears to result in the gradual development of a length of cambium and conducting tissue disproportionately great to the small crown and supply of elaborated food. The cambium and conducting tissue becoming gradually starved, results in a slowly decreasing sap circulation which ultimately appears to cause Spike.

(*d*) *Exposure of trees hitherto growing under shade*:—Such exposure frequently appears to result in an increased loss of water from the transpiring leaves while the roots are unable to proportionately increase the supply available, especially when only the roots of an unsatisfactory host such as lantana are available or the cambium has been poorly nourished owing to a more or less prolonged period of partial suppression.

All the cases of Spike in the sandal hitherto seen by the writer can, it is believed, be explained under the above four headings.

Lantana appears to be particularly injurious inasmuch as it greatly increases fire damage of the kind particularly liable to cause Spike, especially in dry localities, *viz.*, a low fire burning the soil and roots and

scorching the bases of the stems and branches, while doing comparatively little injury to the apices of the stems and branches. It also tends to increase the damage done under heads (*a*) and (*b*) above.

Although sandal haustoria readily penetrate the roots of lantana, these haustoria usually appear to decay quickly which is not the case with a good host like *Acacia suma*, for example. There seems to be little doubt that the enormous increase of Spike noticed in recent years in Coorg is largely due to the spread of lantana.

Additional factors which may cause Spike.

5. From what has been said above, it will be clear that Spike is ascribed to an unbalanced sap circulation caused by a slowly decreasing water supply. Obviously therefore, if the present theory is correct, any factor capable, under some conditions at least, of slowly decreasing the water supply is able to cause Spike. In addition to the four factors mentioned above, therefore, which, in the cases seen by the writer, appear clearly to have been the primary causes of the disease, the following will probably be found to be responsible in at least some cases :—

(*a*) *Drought* acting directly or indirectly through the hosts. Bark-scorching by the sun may often accentuate this.

(*b*) *Bad soil-aeration* which may similarly act directly or indirectly through the hosts. A dense growth of lantana, grass or herbaceous plants, compacting a heavy soil, *e.g.*, by grazing, accumulations of humus and any factor which is likely to keep the soil constantly wet, are all liable to produce this condition which is undoubtedly injurious to the roots of sandal.

(*c*) *Damage by insects.*—Sucking insects which interfere with the circulation of elaborated sap may, in some cases, produce the disease.

Dr. Coleman's grafting results.

6. It may now be argued that the results of Dr. Coleman's grafting experiments clearly prove that Spike is an infectious disease due to a specific organism or virus and that therefore the present theory cannot be correct. It is believed, however, that these results can be explained otherwise than by assuming the existence of a virus or organism. It is known that the action of the enzyme known as diastase is weakened and may be entirely inhibited by an undue accumulation of starch. If a spiked twig packed full of starch is grafted on to a healthy plant, the active diastase in the tissues of the stock acting on the starch in the adjoining cells of the scion may produce locally a quantity of soluble sugars in excess of that which can be rapidly translocated and utilized for growth. This excess would again be deposited as starch in those neighbouring cells of the stock into which the sugars had diffused. The starch thus removed from the spiked scion might again be made good by the manufacture of additional starch in the leaves of the spiked scion. In this way a progressive extension of starch accumulation coupled with a weakening of diastatic activity might take place in the tissues of the stock which would account for the appearance of Spike in the latter.

Spike is not really infectious.

7. Observations in the forest do show that the disease often extends from an infected tree or group of trees in a manner that suggests spread by infection. Assuming that one healthy sandal tree designated *A* is connected by haustoria with the roots of another sandal tree designated *B*. If the latter tree is killed by fire or any other factor, or is spiked, its roots will cease to supply *A* with water. This reduction in its water supply may suffice to spike tree *A* and in this way the disease might gradually spread.

It must also be remembered that one and the same factor, *e.g.*, the felling of host, may spike the less vigorous sandal, or those which are most

dependent on the host more quickly than other more vigorous or less dependent trees. The latter becoming spiked one or two years later than the former, but in their neighbourhood, would also produce the impression of a spread by infection.

That the disease is not really infectious is indicated by the frequent occurrence of isolated cases of Spike several miles from any infected trees and also by the fact that trees quite close to spiked individuals not infrequently remain free of Spike for long periods.

Why sickly trees do not necessarily get Spike.

8. Extremely sickly and more or less "stag-headed" sandal trees may often be seen in open exposed areas devoid of good woody hosts. Such plants frequently remain free of Spike. In such cases, however, the sap circulation, although it may be very slow, may be balanced. The small amount of water taken up from the soil being sufficient for the translocation of the small amount of starch made in the attenuated crown which in its turn, suffices for the nutrition of the small amount of living cambium in stem and roots.

Experiments necessary to prove the theory.

9. An experiment carried out by Mr. Tireman in Coorg has clearly indicated that, even in a fire protected area, the uprooting of lantana has materially diminished the incidence of Spike, which, so far as it goes, clearly supports the present theory. The latter is, it is believed, also supported by all the reliable experiments and observation which have as yet been placed on record regarding the disease. Further, it is obvious that if the theory is correct, conclusive proof regarding it can now easily and quickly be obtained by a few simple forest experiments of which the following are most important :—

(*a*) In localities where there is as yet no Spike, select two areas, as similar as possible in acreage, type of growth and number of sandal trees. Then burn one of these areas annually and protect the other. In this way it should be possible to produce Spike in areas where it is at present unknown. Dry localities, with a small rainfall or shallow stony soil, well stocked with lantana are likely to give the best results.

(*b*) Select 50 to 100 sandal trees, each one growing close to one or two large hosts, the latter being distinctly dominant with reference to the surrounding vegetation. In the case of one half of the selected sandal trees these large hosts should then be felled and their stools dug out, while in the case of the remainder the hosts should be carefully protected from injury. Some at least of the sandal, the principal hosts of which have been removed, should get Spike. In some experiments the hosts should be felled in August and in the others in March. In the former case the effect is likely to be more gradual and conducive to Spike, in the latter case the action may be too sudden resulting in some cases in death instead of Spike. Hosts which readily produce root-suckers should not be selected.

(*c*) Select 50–100 sandal trees which are suffering more or less from suppression and which have lanky stems and branches bearing very little foliage. Expose the crowns of these trees to free overhead and side light by pollarding and cutting away the surrounding growth. One-half of these sandal trees should be pollarded or coppiced at the same time as the surrounding growth is cleared, the other half should be left untouched. The incidence of Spike among the latter should be greater than among the former.

(*d*) It is possible that the effect of gradual suppression might be reproduced by repeatedly pruning off all lateral twigs so soon as they appear, encouraging only apical growth of the stem and branches by allowing only one terminal twig to develop in each case.

(*e*) In localities where there is as yet no Spike in *Zizyphus oenoplia* but where this species is plentiful, select two areas as similar as possible in acreage, type of growth and number of *Zizyphus* plants. Then burn one of these areas annually and protect the other. In this way it should be possible to produce spiked *Zizyphus* in areas where the disease does not at present exist.

It is believed that careful experiments on these lines will furnish conclusive proof of the theory here advanced, probably in one or two years.

Steps necessary to prevent Spike.

10. In anticipation of such proof, however, it may be said that the principal steps necessary to prevent Spike appear to be :—

(*a*) *Fire-protection.*

(*b*) *Elimination of lantana by uprooting.*—The eradication of lantana is cheaper and easier if it is first burnt. If therefore, this is necessary, the sandal should be first coppiced or pollarded and if possible, burning the lantana in the immediate neighbourhood of the trees should be avoided.

(*c*) *Careful Tending.*—This must aim at :—

(i) *Maintaining good host plants near the trees.*—In the dry areas of Coorg, *Acacia suma* appears to be a particularly good host. When lantana is removed, if there is a scarcity of good hosts, the latter should be established as quickly as possible near the sandal trees. This can often be done more satisfactorily and quickly by transplanting fairly large plants, having first cut back their shoots and roots, rather than by sowing.

(ii) *Avoiding severe damage to host plants, e.g., by girdling or felling.*—If the injury to host plants is unavoidable, *e.g.*, when bamboos die naturally, the neighbouring sandal trees should be pollarded or coppiced and unless sufficient good hosts are available, new hosts should be established near them as quickly as possible. A similar procedure should be followed in the neighbourhood of sandal trees which have become spiked. This may enable the plants to make new starts with new host connections.

(iii) *Providing for the free and natural expansion of the crown from early youth.*

(iv) *Freeing very carefully and gradually those trees which have been more or less suppressed.*—Such trees, however, will probably be less liable to Spike if they are pollarded when they are set free.

(v) *Providing light side-shade to avoid damage from drought and sun-scorch.*

(vi) *Providing free overhead light, or, in dry localities, of a very light overhead shade, such as that furnished by* Acacia suma.

(vii) *Not allowing a heavy growth of grass or herbaceous plants to develop near the trees.*—Such plants are bad hosts, providing only a small and uncertain water supply, and are apt to produce a badly aerated soil.

(viii) *Avoiding compacting the surface of heavy soil, e.g., by grazing.*

Additional measures to those enumerated above and which have been recommended in the past are :—

(*a*) Measures based primarily on the assumption that the disease may be communicated through the roots such as *isolating the infected trees by trenches and digging up and removing all spiked trees.*—There is as yet no evidence to show that the disease can be communicated through the roots (otherwise than by affecting the water supply of neighbouring plants) even by grafting, and pending such proof, the utility of such measures appears to be doubtful. Assuming the possibility of such infection, there is no certainty that the disease may not have been communicated before the trench is dug. The digging up of an infected tree also does not necessarily sever the connection between its roots and those of neighbouring

trees. The writer has found a case in which a lateral root of a sandal tree which had been dug up at least one year previously was still alive, apparently healthy and grafted to a neighbouring sandal.

(*b*) *The formation of protective belts by removing all the sandal trees over extensive areas.*—This is not likely to materially check the spread of the disease and will involve the unnecessary destruction of healthy sandal on a large scale.

11. Whatever the value of the theory may be, which is here advanced, it must be noted that its inception is very largely due to Mr. G. S. Hart, Inspector-General of Forests, and Mr. B. O. Osmaston, President, Forest Research Institute, Dehra Dun, who have steadily encouraged and helped the writer in his work; to the kindness of Dr. L. C. Coleman, who showed the writer his most interesting and important grafting experiments; to the accurate observations of Mr. C. D. McCarthy; to the information kindly supplied by Mr. P. M. Lushington; to the work and publication of Messrs. Barber, Butler and M. Rama Rao; and especially to Mr. H. Tireman who has given the writer the greatest help in studying this disease in the forest and whose experiments and progressive tending work with sandal have clearly indicated several of the most important factors which influence the well-being of sandal in the forest.

Acknowledgments

12. Finally, it is possible that the explanation here given of Spike may be found to apply to other highly injurious and hitherto obscure diseases such as Peach Yellows, and that factors checking the healthy circulation of sap, such as injudicious pruning, may be the primary cause of the trouble.

NOTE ON SPIKE DISEASE.

By Mr. P. M. Lushington, Conservator of Forests, Southern Circle.

1. *First appearance.*— In an article on sandal published in "Stray Leaves" in 1895, I referred to what I termed a variety of sandal growing on schisty soils which exhibited small pale leaves found on the Bargur plateau of North Coimbatore. I have constantly wondered if this was Spike though I did not recognize it as a disease at the time. Later on in 1898, in the same district I found hundreds of trees dying in Punachi and was unable to assign a cause. In 1903 a Working Plan was prepared for this area and there was still a good deal of sandal in existence. At the present time Mr. McCarthy informs me that there is no sandal in that place and it seems to be likely that Spike was the cause of this disappearance because Spike is the only known disease which causes the complete disappearance of sandal. I make mention of these points because the disease was reported from Coorg first in 1899 though it must have been existent before that year and it seems likely that the disease must have broken out in North Coimbatore about the same period.

2. *Apparently healthy haustoria from diseased trees*:—Specimens of these have been sent by Mr. Hearsey for examination and I sent some admirable specimens to Dr. Barber which were lost by him.

No trace of disease was discovered in the specimens sent by Mr. Hearsey, but a further examination of haustoria from Spike trees appears to be desirable.

From the examination of the root system of a tree on the Kollimalais, which had very few visible signs of Spike, the evil must have been deep-seated, for there were hundreds of dead root-ends and only one root with apparently healthy haustoria. [*Vide* Board's Proceedings, Forest No. 93, dated 26th June 1916 (Tree No. 1, page 10) and Mr. Latham's corroboration in Board's Proceedings, Forest No. 11, dated 16th January 1917.]

3. *Excess of starch in the leaves and twigs and dislocation of working of the stomata,* (page 13, Coleman. Compare "Life History of Monophlebus," Stebbing, page 153.)—The damage attributed to the insect may be summarised as follows:—

(*a*) The clogging up of the stomata and pores of the twigs by the sugary secretion. This envelops leaves and twigs, etc., with a sticky film which dries in the sun, giving them the appearance of having been varnished. If the year is wet the film is rapidly dissolved off by rain, but in dry seasons it remains for several months *in situ.*

(*b*) Twigs and small branches dry up and die off under the excessive tapping. This latter has a most serious effect upon the development of the Spring crop of leaves and upon flower panicles which open in April. The production of the seed is thus probably considerably interfered with

(*c*) The damage caused to young saplings is perhaps even more serious as the insects congregate round the leading shoot and the upper side ones, extending down each for several inches in a serried mass. The leading shoot is often killed and side ones take its place, and the young

sapling takes on a crooked habit of growth most detrimental to its future value as a forest tree.

This is written of the attack on the sal, but if it were applied to sandal (and we know these bugs to abound in sandal areas) would not the blocking of the stomata account for the excess of starch and are not the other phenomena, *viz.*, the effect on the development of spring leaf, on flowers and seed precisely what are found as the overt signs of Spike ?

Besides the *Monophlebus* we have the *Iceryas* and the *Walkeriana* in the forest which develop this sugary secretion and suck in precisely the same way.

4. *The similarity of the disease in other species.*—This, in my opinion, is one of the most important parts of the enquiry. *Zizyphus, Tephrosia, Crotalaria, Vinca, Stachytarpheta and Datura* are said to show similar phenomena, *viz.*, excess of starch, reduction of the leaf area, paler colour, short internodes. In the case of *Zizyphus* dead root ends are also noticed.

To this list we can now add *Olea cuspidata, Dodonœa viscosa* and *Scutia indica*. On the other hand, there are no indications of excess of starch in the *Albizzia lebbek* Spike.

Now in working with *Monophlebus* and *Icerya*, though we have infected sandal trees and apparently produced unhealthiness and even death, we have not produced the essential forms of Spike and though we have, as I have shown above, considerable reason to believe that the phenomena of Spike may be produced by these insects, we cannot be said to have been able to really connect them with the spike-like appearance.

On the other hand, we can undoubtedly connect the Psyllidæ with Spike. Not only has Bainbrigge Fletcher pictured the spike-like appearance caused by Psyllidæ in a species of indigo, but we have specimens of *Cassia fistula, Albizzia lebbek*, and *Scutia indica* in which there is little doubt that an agglomeration of leaf and phyllody of flowers is produced by this class of insects. Only *Albizzia lebbek* has been examined and this shews no excess of starch. So it is too early to pronounce definitely whether this is true Spike or not.

But are we certain that excess of starch is an essential of Spike in its *earliest* form ? At Rayakota we have a form of "lanky degeneration" which in its early stages shews a lengthening of leaf and internodes and it is only in its latest stages that clustering is seen. Last year I refused to say that this can be termed Spike as it presents different characters, and Dr. Coleman failed to find the excess of starch in the twigs and leaves. Since that time Mr. Hearsey has made some important observations tending to shew that this is an early form of Spike by having found it

(*a*) associated with abnormal flowers (pages 9 and 10);

(*b*) associated with true Spike

(i) on tree No. 25, Tholuvabetta (page 13);

(ii) in the newly spiked area on the Javadis.

Now in the *Dodonœa* we have a connecting link; for this shrub conspicuously exhibits the "lanky degeneration" as well as the true form of Spike. In addition to Mr. Hearsey's observations I have seen it prominently at Kulivalavu on the Kollimalais and in several places in Tinnevelly, but ordinarily outside the sandal area. The connection however is rather disconcerting because in this case Dr. Coleman has, contrary to his experience in sandal, found excess of starch in the lanky form as well as in the bunched form.

Perhaps I ought to have stated at the outset why I believe in an earlier manifestation than the official Spike form. On page 41, Dr. Coleman

has shown the period of incubation to be of some length and has stated that there are internal symptoms (excess of starch and death of the root ends) to be found before the actual Spike appears. But of all Dr. Coleman's grafting experiments the one that most closely resembles nature is that pictured in Plate XVI, Fig 1, and described on page 40. Now in this case the grafting took place on 29th November 1915, long after it was known that the tree had been poisoned as outward signs were visible. Accumulation of starch was found in August 1916 (9 months after grafting) and no fresh flush of leaves took place for sixteen months after grafting. Dr. Coleman has not published his full observations on this most interesting experiment, but I hope I may be permitted to state that spike only appeared with the new flush of leaf, eighteen months after the grafting.

Now I understand that in this case there was no preliminary outward manifestation and this is certainly against the theory that " lanky degeneration " is an early sign. Everything, however, root examination and the fact that we only find developed Spike in trees which are doomed to die, seems to show that the period of incubation is even longer in nature than in this case.

The actual poison injected by nature is probably even smaller than that injected by grafting, whilst the trees being as a rule larger, are more capable of resisting this small amount of the poison. Is it not possible to conceive that nature promotes an excess of growth even before the first signs of starch-poisoning are manifest ?

This excess of growth is seen

(*a*) in the lengthened internodes;

(*b*) in the enlargement of caducous bracts;

(*c*) in the phyllody of the flower.

5. *Endemic attacks of Spike.*—In Mysore and Coorg soon after the first appearance of the disease, large areas were swept away and the natural conclusion was that the disease was very infectious and Dr. Coleman's experiments have confirmed this view; but later observations seem to point out that the disease is also in some way endemic. My first experience of Spike, as far as I can state definitely, was at Germalam in North Coimbatore in 1903. This was then an isolated area and it was only subsequently that I saw Spike at Hassanur and Thattakarai. Now all these were isolated areas but possibly there may have been links between, as our observations were not so carefully conducted as now. McCarthy's first observation of Spike in Javalagiri was an isolated tree. Wilson trenched a single tree on the way to Tholuvabetta. Tholuvabetta is still an isolated area. Latham found a single tree at Salem. An isolated patch of 67 trees was found on the Kollimalais. An isolated area was found on the Pachamalais by myself and finally at Neivasal on the Javadis, subsequently verified by Mr. Hearsey. What then can be the possible explanation of these isolated patches ? Dr. Coleman has referred to—

(1) *Fungus.*—Negatived by Drs. Barber and Butler and almost every subsequent investigator, though Mr. Latham apparently still believes in the fungus theory.

(2) *Carriage of seed by birds.*—A possible theory; but if this were so, would not the disease make its first appearance amongst the seedlings ? Though seedlings are not free from attack, as was once thought to be the case, yet the disease in the sapling and tree are of far more frequent occurrence.

Again one can hardly conceive that birds would fly over five miles before depositing the seed.

Mr. Hearsey has since informed me that the flying fox carries the fruit and eats and deposits the seed at long distances from which the fruit has been obtained. This is a possible method of dissemination of unhealthy seed at a distance.

(3) *Infection through other species.*—This is a very possible theory. We find a disease similar to Spike in *Zizyphus*, *Dodonœa*, *Jasminum* and other species in districts where sandal is either absent or of rare occurrence. The prevalence of " clustered leaf " is now known to be far more common in other species than was formerly suspected. This side of the question has been rather neglected and it is only recently that I have asked Mr. Hearsey to trace out the roots of these diseased species and see if the sandal is connected with them. We have, however, evidence that the disease in *Zizyphus* does not necessarily lead to the infection of sandal even after long periods. The most typical example is the Palamalai of North Coimbatore. As long ago as 1903 I observed diseased *Zizyphus* in this sandal area and yet the sandal of this isolated hill remains free of infection up to the present time.

But when all is said and done and even if we prove that sandal can be infected by other species, we still have to prove how the disease is caused in those species.

(4) *Insect attack.*—This has for many years now appeared to me to be the most likely cause of Spike. It is true that originally I suggested fire, but the more we study our forests the more are we impressed that our forests are harbours for the most virulent insects. Our very protection from fire must undoubtedly increase the myriads of insects and it is hard to think that our very careful protection from fire in sandal forests may be the cause of Spike having originally shewn itself in comparatively recent years. Sandal is so susceptible to fire that constant fires will soon wipe it out and yet by our careful fire protection we may be increasing enemies even more dangerous than fire. Drs. Barber and Butler very quickly discarded the insect theory and it is surprising that they should have been unaware of the numerous kinds of sucking insects which are doing damage to our forests and among them, the sandal forests.

I have already called attention to the production of spike-like appearance produced by the Psyllidæ and to the possibility of Monophlebus being able to produce all the phenomena of Spike Disease. But in addition to these, I may pass over for the time amongst the Fulgoridæ, *Ricania fenestrata*, *Eurybrachys tomentosa*, *Messena sinuata*, *Pulastya acutipennis*, *Melicharia lutescens and Flata* sp., all of which are found in numbers in our forests. The *Eurybrachys* and *Melicharia* were for some time suspected, but our experiments and observations seem to lead to the conclusion that they are comparatively harmless.

But apart from these we have found in large quantities—

(1) Red spider (*Arachnids*) several species.
(2) *Icerya* (2 species).
(3) *Walkeriana cinerea.*
(4) *Dactylopius citri.*

I need not repeat Mr. Hearsey's observations but I do wish to point out that we have in our forests innumerable insects (scientifically I am not allowed to include the red spider) which are known to be most serious pests.

I have collected from the Research Institute and elsewhere all that is known of the red spider and his confreres and I find it to be a devastator of tea gardens in Assam, Cachar and Darjeeling. In 1880, the pest had

become so serious that a general request was made that an expert should be sent to the tea districts to investigate this pest along with mosquito blight. We have heard very little of this pest in Southern India though Bainbrigge Fletcher gives his distribution "probably throughout the Tea Districts of Southern India." It is possible that our tea districts are comparatively immune from serious attack on account of their high elevation and abundant rainfall.

In the drier tracts of North Salem, Tirupattur and the spiked area recently found in the Kavadis, this *Arachnid* is found in myriads and Mr. Hearsey believes it to be the cause of Spike in *Dodonœa* and other species, and possibly in sandal. In California the *Citrus* groves are infested with this insect and the most elaborate precautions are taken against them. They are distributed by wind, coolies' clothes and probably by other agencies among which Mr. Hearsey mentions herds of cattle. In our forests they are allowed to breed and distribute themselves without let or hindrance and the only restrictions placed on them are due to natural causes—the advent of heavy monsoon and their natural enemies.

Icerya :—I can find very little literature on the subject of this insect but there is no doubt that it is a well-known pest in Egypt, where it is most destructive to field crops. So great was the fear of this insect spreading that when a single specimen was introduced to England it was quickly put to death as soon as it had been described. Apparently in India we are callous as to its existence though it is widely spread in gardens and thrives on some of the crotons. I have seen masses taken from a garden at Shembaganur, 6,000 feet in elevation, and we know from Mr. Hearsey's report (page 23) that 6 bugs in 6 months had increased to 112 per leaf. What then must be the myriads of these insects harbouring in forests and gardens and yet, up to date, I imagine there are very few Forest Officers who know of their existence or know them by name, their mere existence in Southern India being apparently only discovered through a lady gardener.

Walkeriana cinerea :—This is another of the sucking bugs of which very little is known. It is not in such abundance in our sandal forests as some of the others but has been found in considerable numbers. We know that it has been found in large colonies on babul trees, one of the commonest trees found throughout the length and breadth of India. We know practically nothing of the damage done by it, but we can imagine what opportunities it has for multiplying. Mr. Hearsey tells us on page 26 of his report that the branches and branchlets on which it feeds die off.

Dactylopius citri.—This needs very little comment as it is the famous "Mealy bug" of Southern India and its ravages in the coffee estates of India are well known. It has been found so far only in small colonies in our dry sandal forests but one can imagine that, if a search were made, it may be found in enormous numbers in the moister Coorg forests.

To these four very dangerous classes of insects, I wish to add a fifth.

Monophlebus.—I have noted on this above, but a perusal of Mr. Stebbing's note will show in what countless myriads they are found in the Siwalik sal forests. To this may be added Mr. Troup's testimony :—

"On the afternoon of the 6th February 1913, I observed *Monophlebus* insects crawling about the ground in myriads over a large extent of ground in the sal forest near Surbar in Gorakpur Division, U. P. Specimens are sent herewith. I noticed them first on a dusty road going through the forest. The insects were crawling in the dust, leaving curious worm-like sinous tracks which traversed the ground in every direction

and gave a curious appearance to the ground surface. It is probably safe to say that there was at least one insect per square inch over many acres examined.

The sal is losing its leaves early this year (*i.e.*, in the beginning of February) and on the under surface of the falling leaves numbers of these insects, not more than $\frac{1}{10}$" long, may be found, pinkish in colour with shed skins beside them."

Now this insect is rampant in the spiked areas of North Salem and the Javadis. I have also found it in the spiked area of the Pachamalais and Mr. Wilson brought me a specimen found in the teak forests of Mount Stuart (South Coimbatore). It is evident then that it has a wide distribution in Southern India.

The conclusions I arrive at from an examination of the insect side are :—

(1) That we have the Psyllidæ which are known to produce a crumpling of leaves resembling Spike ;

(2) That we have five other well-known pests, (capable of producing disease in tree growths), in vast numbers in our sandal forests, found in close connection with spiked sandal and other species which have spike-like diseases ;

(3) That we cannot afford to neglect an examination of all these insects and their habits apart from Spike, seeing how great is the damage caused by them both to forests and field crops. That this examination becomes all the more important since their association with Spike has become known ;

(4) That with the knowledge which we have at present, we must, in taking measures to combat Spike, take measures against these insects and that such measures are as important, if not more so, than measures taken for the removal of infected trees ;

(5) That experiments made in the Research Institute show that trees grown in a well-weeded soil are far better than those grown amongst grass and creepers. We have here a further incentive to keep down grass and obnoxious weeds as it is probably harbouring insect pests.

5. *External factors*, (*Coleman, page* 21).—I think it here necessary to quote from Dr. Coleman :—

" In connection with the study of Spike Disease, a large number of external factors have at different times been cited as the cause. Among these may be mentioned the occurrence of fires, the presence of lantana, overgrowth of climbers, etc."

In the preceding para, I have dealt with the danger of grass and climbers as being harbourages of noxious insects. I wish here to lay stress on the lantana theory. Many officers in lantana-covered districts have held Spike to be due to the presence of lantana and even at the present day that view is held. It seems to me that it is far more likely that the lantana may be a harbourage for insects which are either causing disease in the lantana itself and through it the Sandal, or are directly causing disease in the sandal using the lantana as a place of refuge at certain times of the year against enemies. As far as I know, such areas have never been searched for insects systematically and I strongly advise that this should be done without delay.

In connection with this question of external factors, I would mention here that experience is now beginning to teach us that sandal is by no means the delicate plant that it is sometimes considered. Its root parasitism is well known but experiments being conducted on the Javadis are

making us begin to doubt if it is an obligate parasite. We have now had under observation for over a year, six trees which were trenched round, one in February 1906 and five in August 1916. Roots were cut through and on the outside of the trenches there are vigorous root shoots. The platforms themselves are kept scrupulously clean. In spite of the deprivation of nourishment there is no apparent loss of vigour in any of the trees. We have, in another place, tried to produce Spike by deprivation of nourishment and actual poisoning. The root system was exposed, many haustoria cut off and the roots pricked deeply with a nail and then soused with fairly strong sulphuric acid. The experiments were carried out towards the end of 1906. There are up to date no signs of abnormality in the trees experimented upon.

One field characteristic of Spike does not appear to have been recorded. True Spike does not appear to be a creeping disease but sudden outbursts are found at definite periods of the year. What these periods are have not definitely been determined, but Mr. Hearsey thinks that one period is during the hot weather and another when the tree is putting out its new leaf.

I consider it of the greatest importance that Dr. Coleman should assist us at the present time by a more complete description of what took place with regard to the experiment described on page 40. This would enable us to see if the phases through which this sapling went can be confirmed by field observations. Another remarkable fact is that though Dr. Coleman has infected his garden with Spike since July 1915 and has continually been infecting it more and more, we have not yet heard that the healthy plants in this garden or in the neighbourhood have been infected naturally by the poison introduced. I would like to suggest, though possibly this may have been done already, that some of the apparently healthy trees in the compound may be examined to see if they are showing signs of excess of starch.

7. *Dr. Coleman's conclusions.*—With respect to these I am for the most part in agreement; but with regard to (5) I consider too little attention has been paid to the noxious insects known to exist in spiked areas, though Mr. Hearsey's observations have to a large extent supplemented our knowledge on the subject.

I cannot agree that there is yet sufficient material to show that we can arrest the disease by removal of all spiked sandal. Though we may remove some part of the infection, we cannot be certain that we are not leaving behind far greater sources of infection in leaving behind the trees which are infected and do not as yet show Spike. In addition, we have all the 400 and odd other species which show resemblance to Spike which may be sources of infection. Cleared lines are in my opinion of no use at all in arresting the spread. The more we study the question the more we see the numerous cases of the sporadic spread of the disease as I have shown in para 5. Finally, the more we learn of Spike the more we become persuaded that we are only cognizant of the first rudiments of the growth of sandal. Far less are we in a position to propose measures for combating Spike until we know more about its cause and the earlier phases of disease.

EXTRACT FROM THE SECOND REPORT ON THE INVESTIGATION OF SPIKE DISEASE IN SANDAL.

By Mr. T. N. Hearsey, Special Spike Investigation Officer, Madras.

* * * * * *

I am convinced of the truth of the statement "that 'Spike' whether in sandal or in *Zizyphus*, and numerous other species, is identical." The bunching of leaves appears to be due in many cases to attacks of insects belonging to the *Fulgoridæ*, *Psyllidæ*, and *Coccidæ*. To these may be added the red spider (*Arachnidæ*) whose influence on plant life in the forest has recently come under closer examination. There is little doubt that Spike takes a long time to show itself in its natural state, though the actual period remains to be discovered. Dr. Coleman's experiments show that when the virus of Spike is introduced artificially, it takes a long time to develop and the natural development of the disease is in all probability an even slower process.

In para 8 of the first report reference is made to certain experiments carried out by placing the *Monophlebus* bugs on healthy sandal plants, the results of these experiments are treated of under the description of *Monophlebus* or grey bug, etc., *infra* page 39.

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3. I consider it necessary to give the description of sandal as stated in the books of reference and I quote from the late Sir Dietrich Brandis' "Indian Trees" and from the "Flora of the Bombay Presidency" by Theodore Cook, C.I.E., These descriptions follow more or less the description given by Hooker in his "Forest Flora."

Idiosyncracies of Sandal.

After nearly a year's intimate acquaintance with sandal, several idiosyncracies of the tree have been noticed which appear to have escaped the notice of most Forest Officers, as far as the flowers and leaves are concerned.

Normally the sandal flowers are four-lobed, brownish-purple in colour on short pedicels, with minute bracts *which are early deciduous.*

Leaves are stated to be from length $1\frac{1}{4}''$ to $2\frac{1}{2}'' \times \frac{5}{8}''$ to $1\frac{1}{4}''$ breadth.

Flowers:—By actual observation, it is found that the descriptions are very far from complete, for the flowers have been found to be actually from *three*-lobed to *six*-lobed; pedicels from very short to very long, in many cases attaining one inch in length. The colour also varies from pale green when the buds have just opened, turning to dark brownish purple, as the flowers mature; such flowers have been kept in spirits for reference.

Leaves opposite, distichous, from $1''$ in length to $\frac{1}{2}''$ in breadth and $5\frac{1}{2}''$ in length by $3''$ in breadth; the small-leafed tree which is invariably found on dry soil in exposed localities, leading a novice to imagine that

the tree was spiked. These trees have their leaves yellowish in colour whilst the large-leaved trees are found in moist rich soil and have invariably very dark-green shining leaves.

Abnormality :—Leaves have been found in many instances to be truly alternate : verticilliate ; in very rare instances in fours, and quite commonly in threes and also in many cases all three forms are present on the same tree, *i.e.*, alternative, opposite, distichous, and verticilliate. In one particular case (Tree No. 9 of Hanumantharoyanagudi series) five new branchlets appeared in a bunch and all five are verticilliate in *threes*. In several cases, seedlings developed in verticils of threes.

Reason for abnormal leaves :—So far, I am of opinion that this abnormality in leaves is due to an undue activity in growth owing to two principal reasons. Firstly, in localities where Spike is present, the spiked and infected trees show this abnormality very conspicuously and it is a fair inference that the virus may be producing the abnormality. Secondly, in healthy localities where no Spike poison is presumed to be present this abnormality seems to be due to attack by one bug (*Icerya* species) in particular and possibly by other species. In both cases a rapid activity in growth and mal-formation of buds takes place and the leaves and branchlets which are formed develop into verticils of threes and sometimes fours. The internodes are abnormally lengthened, making the young growing shoots appear lanky and over-grown. This abnormality will be treated of under the head of experiments further on in this report.

Thickened leaves :—The thickening of leaves is a curious phenomenon. Usually, leaves become thickened during the season of rest, between the months of November and March when the leaves are shed naturally and new buds are formed at the bases. It has, however, been noticed that during and even after the growing season has stopped, thickened leaves are present. Such leaves are stiff and abnormally thick, very brittle and break with a snap. An instance of this is tree No. 4, Hanumantharoyanagudi series. This tree was discovered in June 1916, covered with thickened, bronzy-looking leaves and these thickened leaves were visible in every month, up to end of April 1917. It has still got a large proportion of these thickened leaves. The root system of tree No. 3, Hanumantharoyanagudi series which had bug on it in May 1916, and had conspicuous thickened leaves, was thoroughly examined in August 1916 with the result that many dead and rotten haustoria were found and several of the root ends were dead. There was, however, a large proportion of living and apparently healthy haustoria.

Tree No. 1. *Aiyur observation series.*—This tree was, to all appearances, quite healthy and normal in May 1916. In June and July 1916, a large number of grey bugs, *Monophlebus*, about 250 in number, were placed on it. A month after, the tree developed curious crinkled and twisted leaves. These leaves became thickened in August 1916 and have remained thickened for nine months.

Crinkled leaves :—This curious phenomenon accompanies thickened leaves and I may say that it appears to be the first outward sign of an unhealthy state of affairs with the internal economy of the tree *above ground*. By careful observation extending over a period of nine months, it is found that it precedes the appearance of Spike in spiked areas. It remains to be seen what happens in the suspicious areas where it is present along with the thickened state of the leaves.

Fall of leaf :—This is another curious phenomenon accompanying the state of crinkled and thickened leaves. Normally, just before the season

of growth takes place, the old leaves fall off and are replaced by new growth. But from actual experience, it has been found that in all unhealthy trees and trees attacked by bugs, as also in suspicious and spiked areas, the trees shed their leaves far too often. In some cases the leaves shed are apparently quite green and healthy and clearly immature. I have cases on record where there has been a continuous fall of leaf immediately replaced by new leaf, which in its turn, thickens and falls off permanently. It certainly appears to have something to do with the future appearance of Spike, but, there has not been sufficient time to form a definite opinion.

Abnormal flowers :—Now, I come to the case of abnormality in flowers. I had found abnormal flowers, *i.e.*, when the lobes of the flowers were more or less modified into leaves in spiked trees, in the month of November 1916, and thought nothing of this, taking it for granted that such abnormality was normal in the case of actual spiked trees. It was only when the Conservator informed me that such abnormality was quite a rare occurrence that I looked into the matter closely.

My attention was drawn to a tree (sandal) that I had " bugged " in August 1916, in my garden at Vellore. This tree developed very curious flowers in November 1916. The chief point was that the ordinary minute deciduous bracts were *conspicuously lengthened and persisted, for an unusual length of time.* This happened only on a few branchlets ; on others, the flowers were quite normal. These were shown to the Conservator personally and specimens were sent to Dr. L. C. Coleman of the Agricultural Department, Bangalore, who pronounced that the flowers were abnormal but that, there was no indication to show what was the cause.

In the second case, an area at Royakota, Salem District, was discovered with what I hold to be the " first form " of Spike *in a newly spiked area.* This will be treated of further on in this report. Tree No. 11 in this observation series was found with very conspicuous abnormal flowers, when the bracts were quite $\frac{1}{4}''$ in length and there was further abnormal branching in the flower buds. Specimens of these were sent to the Principal, Madras Forest College and Dr. L. C. Coleman. Both admitted the abnormality but could not account for it. The latter could find no starch deposits in the cells to indicate the presence of Spike.

It has been said that a spiked tree does not produce flowers and fruit. Yet, normal and abnormal flowers have been taken from fully spiked trees, as well as, unripe and ripe fully formed fruit. These are preserved in spirits and samples were sent to Dr. Coleman. Seed from such trees has been secured and sown in a special locality at Aiyur to see if it will germinate or not, with a view to ascertaining whether such seed gives rise to Spike seedlings. On the other hand, if healthy seedlings are produced, it is possible that the plants may be found to be naturally spike-resisting. In the trees referred to above, apparently the flower buds are developed before Spike appears, subsequently Spike overtakes the branch on which the flower buds have been formed and the flowers gradually become modified though some develop into flowers and fruit. It has also been found that fruit formed from abnormal flower is, as a rule, cast prematurely. A fine collection was made of abnormal flowers, preserved in spirits, showing the gradual modifications of the floral envelope ; these were sent to the Conservator. It has since been ascertained that this abnormal development in flowers, is quite a common occurrence in spiked trees.

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First Sign of Spike.

Below Ground :—The following is tentative and open to correction as knowledge in the subject increases :—

The first sign of Spike is to be found in the root system ; several trees not showing Spike outwardly, except crinkling of leaves but on which bugs were found in July 1916 (in the spiked area) were examined in September 1916. The root system showed the ends of the roots dead and dying and the haustoria dying from the base outwards. These trees developed Spike in March 1917.

Whilst trees just showing Spike had almost all their haustoria dead and dying, with just a few at the extremities of the root ends still alive and in many instances discoloured, the root ends in most cases were dead. In the case of suspicious trees, as for instance, Tree No. 3, Hanumantharoyanagudi series, the root ends were just beginning to die ; so also the haustoria, along certain roots only.

In the above ground appearance.—The very first sign appears to be the crinkling of the leaves, followed by thickening. Then there appears to be a long, quiescent period when the tree is either developing energy or " little Mary " is upset. Then there seems to follow a period of ever increasing energy the frequent fall of immature leaf and the formation of abnormal flowers in a few branchlets. Then the first form of Spike appears.

First Form of Spike.

The appearance of this is the rapid formation of leaves and their rapid fall, the lengthening of the internodes, then the drooping of the long pendulous branchlets and the formation of long thin limp leaves.

Second Form of Spike.

The second form of Spike appears in the form of the gradual shortening of the internodes, the more rapid fall and renewal of the leaf and the dying off of the branchlets and tips of branches. There is then a very great display of energy and suddenly true Spike makes its appearance here and there ; in some cases a tiny branchlet shows it, in other cases, most of the terminal ends show it together, whilst intermediate stages are frequently observed.

Judging from the Royakota area wihch I call a virgin spiked area, the first lot of the trees seem to die off in the " lanky spike " stage ; and as the poison spreads from tree to tree it appears to gather strength and seems to approach the true Spike form.

I was passing the Royakota Railway Station, last May (1916), when I happened to look out and saw three or four sandal trees with what looked like Spike, from a distance. I sent Ranger, Mr. Salisbury of the Dharmapuri Range to carefully inspect the area, to report and to send pressed samples. He reported that about 70 per cent. of the trees appeared healthy and sent me four samples, one of which he said, he thought was Spike. It had all the appearance of true Spike and I have the specimen still with me. Soon after I went to the spot and found some twelve trees situated in an isolated knoll surrounded by cultivation. The undergrowth had been fired some two months previously, and three of the trees were badly scorched. Four (*a*, *b*, *c*, and No. 2) of these trees were showing the first form of Spike (lanky form). One tree was dying (*a* in the sketch attached) ; perhaps death was accelerated by fire. I also found a number of

root-suckers in another garden that were exhibiting suspicious signs. On all these trees I found bugs (*Monophlebus* species). In October 1916 the area was visited by the Conservator and the form of Spike not considered by him to be "true official Spike." Two more (*b* and *c*) of the first lot of trees had died in the meantime and one (No. 2) was three-fourths dead. Tree No. 3 was then fully spiked with the lanky form of Spike. The leaves of this tree (No. 3) were sent to Dr. Coleman but he could find no trace of starch deposit in the cells. In February 1917, more leaves of this same tree were sent to Dr. Coleman and he then found appreciable traces of starch and the inference therefore, is that it was approaching the form of true Spike, as the leaves were taken after the season of rest. The *tree actually died in the month of March* 1917, barely one month later. Tree No. 5 had then, in February 1917, half its leaves showing the first form of Spike and half normal in appearance. In these leaves, Dr. Coleman could not find starch and it was then that tree No. 11, as well as others were exhibiting abnormal flowers. The future behaviour of this group is to be carefully watched and recorded.

Now, in the Tholuvabetta spiked area, tree No. 25 was taken as a type of spiked tree, showing all the three forms of Spike (see page 4 *supra*) and it was photographed and botanical specimens kept.

In October 1916, a newly spiked area was found in the Thally Reserve by Deputy Ranger Chathu Nair and his verbal description tallied with the first form of Spike at Royakota. This area is said to have rapidly developed and is shewing true Spike. The undersigned has not, however, personally inspected this area.

5. *Temporary arrest of the spread of Spike in individual trees:*—Observations have been recorded as to what would happen if branches and branchlets showing Spike were cut off. In five marked trees, this experiment has been carried out. It is so far ascertained (10 months of careful observation) that Spike is temporarily arrested by this means, but, its action is irregular as Spike follows no hard and fast rules. Two similarly attacked trees, show that the tree on which the spiked branches were not severed, developed Spike throughout within six months' time, whilst the trees whose spiked branches had been cut off from time to time, as the Spike showed itself, have not become fully spiked within ten months. I have a tree, for instance, (No. 25 of Tholuvabetta) that was not showing any Spike in June 1916. This tree was not interfered with in any way, but by November 1916, was fully spiked. On the other hand, tree No. 1, Tholuvabetta, first showed one branch with Spike, which was severed on 8th September 1916. A second branch developed Spike *above the first* and was severed on 2nd December 1916; a third branch showed Spike above the first two and was severed on 5th March 1917. Up to May 1917 it was showing no more Spike. In five other trees where branches were lopped, the disease has evidently been arrested and none of these as yet are completely spiked.

6. *Other species besides sandal exhibiting spike-like growth.*—Besides sandal, I have now 37 species of trees exhibiting growth, that has the appearance of Spike, and in the case of *Zizyphus oenoplia, Vinca rosea, Stachytarpheta indica, Dodonœa viscosa,* the spike-like growth on these species has been pronounced to be allied to Spike in sandal. In *Olea cuspidata and Cipadessa fruticosa* an excess of starch has been found by Dr. Coleman, but the "form" of the spike-like growth differs somewhat from the true Spike of sandal, though the abnormal phyllody is present. I give a list below of the species, so far met with, that exhibit this form

of disease and there is no doubt, that many of them die from this cause. Other species, however, do not appear to suffer badly or are able to work off the poison, such as, *Cassia fistula* and *Zizyphus xylopyra*. *Argyeria cuneata* is peculiarly susceptible and dies off completely within a year, whilst *Zizyphus oenoplia* seems to die off fairly soon after attack. In several instances, marked creepers have died within a year also. In the case of *Dodonoea viscosa* there are two distinct forms of Spike, the lanky and the short or true Spike. Both forms were examined by Dr. Coleman and were found with excess starch and therefore akin to Spike in sandal. The lanky form has a curious appearance, the internodes and leaves are greatly lengthened and thickned and grow more or less in a curve, the immature leaves fall off rapidly and the branches die off. Subsequently there is a fall of the old leaf also and at the next renewal a large quantity of buds are developed on the stem, sometimes close to the base, sometimes higher up, and the short form of Spike is then developed. After this, the bush dies very rapidly producing successive growth of smaller and smaller leaves.

List of Trees showing Spike-like Growth.

1. *Zizyphus Oenoplia* (bear fruit creeper).
2. *Dodonœa viscosa* (Pandari).
3. *Vinca rosea* (Periwinkle).
4. *Argyreia cuneata.*
5. *Barleria mysorensis.*
6. *Toddalia aculeata.*
7. *Acacia sundra.*
8. *Canthium didymum.*
9. *Olea cuspidata.*
10. Species of *asclepiad* creeper with fine narrow leaves (not identified).
11. *Scutia indica.*
12. *Dendrocalamus strictus* (very rare).
13. *Dichrostachaye cincrea.*
14. *Ficus infestoria.*
15. *Jatropha gossipiformis.*
16. *Loranthus* (pale-leafed species not identified).
17. *Cassia fistula.*
18. *Cassia auriculata.*
19. *Tephrosia purpurea* (wild indigo).
20. *Vitex negundo.*
21. *Albizzia lebbek.*
22. *Solanum jacquini.*
23. *Terminalia tomentosa.*
24. *Terminalia chebula.*
25. *Butea frondosa* (rare).
26. *Stachytarphtea indica* (*Aaronoa rod*).
27. *Randia malabaricus.*
28. A plant called *Kupparmani* in tamil (not identified).
29. *Pterocarpus marsupium.*
30. *Zizyphus xylopyrus.*
31. *Acacia pennata.*
32. *Acacia leucophlea.*
33. *Cæpadessa fruticosa.*
34. *Flacourtia ramontchi.*
35. *Erycibe paniculata.* (A large creeper).
36. *Randia dumetorum.*
37. *Rabelia robusta.*

Besides the above 37 species, there are other species reported from other districts that have not yet come under my personal observations.

Investigation as to the cause of this growth (Spike) is being carried on by experiments.

Lines of Investigation.

This has been based on the supposition that there is some medium conveying the poison from tree to tree and with this idea in mind, a most careful systematic search both in spiked and suspicious areas, has been carried out. The list below gives the insects so far found actually preying upon sandal :—

(*a*) Red spider—family *Arachnida*.
(*b*) Grey bug—family *Coccidæ*, *Monophlebus* species.
(*c*) *Dactylopius* species (mealy bug).
(*d*) Stellate bug (*Icerya* species).
(*e*) Denkanikota bug (*Icerya*, second species).
(*f*) *Psylla* species.
(*g*) *Walkeriana cinerea*.
(*h*) *Euribrachys tomentosa*.
(*i*) *Messena sinuata*.
(*j*) *Pulastya acutipennis*.
(*k*) *Flata* species.
(*l*) *Melicharia lutescens*.
(*m*) Brown scale.
(*n*) Green scale.
(*o*) Conical scale.
(*p*) White scale.
(*q*) *Ricania fenestrata*.
(*r*) Black looper caterpillar.
(*s*) Two species of small white leaf-defoliating beetles.

An outline is given below of each insect, of the attack, and so far as known, the result of attack of each one of the above enumerated insects. Later on, as full notes are obtained and the life histories and results worked out, separate full notes will be submitted as a supplement to this report.

(*a*) *Red spider* :—This minute insect was originally found at the start of the investigation and was put aside as of no consequence. It was not realized that, though being a spider, it could suck and live on the juices. It is to be met with early in February and in increasing numbers up to end of May, after which period it appears to decrease in numbers, but has been found in small colonies on the under surface of leaves up to the present time of writing (July 1917). The decrease is possibly due to heavy rain after this period.

It has been found on spiked and unspiked sandal and in suspicious sandal areas on sandal, and on most of the species exhibiting the spike-like growth, especially on *Zizyphus oenoplia*, *Dodonæa viscosa*, *Argyreia*, *Cipadessa*, *Erycibe paniculata*, *Vinca rosea*, *Stachytarpheta*, *Solanum jacquini*, *Embelia robusta*, *Jatropha* and *Scutia indica*.

They first appear on the under side of leaves as minute shining, globular dots, and cannot be seen without the aid of a strong magnifying glass. A few days later, they appear as tiny mites, of a pale, yellow, and in some cases of pale green colour.

Having no literature at hand, I considered all to be of one species but since then I have ascertained that " Watt and Mann " have described three or four species, (*vide* Pests and Blights of the Tea Plant pages 372–406), whilst in America, it is stated that seven species are known.

So little is known of this insect that I would be afraid to "make" species. I can merely mention the following :—

1. A pale yellow (young stage presumably).
2. Pale green do.
3. Dark green (older stage).
4. Pale red do.
5. Green with a decided dark saddle back mark.
6. Dark red.
7. A very deep sanguinious verging on deep brown.

The first four appear to me to be the same insect, possibly being only seasonal forms, and have been found on sandal, *Zizyphus oenoplia* and *Cipadessa*.

No. 5 is a large insect and quite distinct and has so far only been found on *Erycibe paniculata*.

No. 6 has been found on *Dodonæa viscosa*, *Argyreia cuneata* and *Solanum jacquini*.

No. 7 is found on *Jatropha gossypiformis*.

They are found only on the under sides of leaves both on old and new growth and very sparingly on spiked portions of the plants. At a certain period they swarm on the under sides of leaves. The first sign of unhealthiness is the withered and rusty appearance of the leaves. The attacked leaves soon fall off apparently after the spider has left the plant and cannot be found. With the aid of a magnifying glass minute cast off skins are to be seen on the under side of the leaves.

Zizyphus oenoplia has been badly spiked at Vellore in the compounds of the Collector and the Deputy Inspector-General of Police. A careful search was made in January, February and March and red spider was discovered in swarms on the under sides of leaves, in small numbers in January, increasing in February, and in swarms at the end of February and beginning of March. These *arachnids* are not found on the diseased portions, but only on the new leaves, on branches not yet diseased, and on the foliage of surrounding creepers.

Argyreia cuneata, *Cipadessa fruticosa* and *Dodonæa viscosa* have been badly attacked by this insect, near the Jowlagiri Forest bungalow, in April this year, and several plants are now (end of June 1917) exhibiting the first appearance of Spike, *i.e.*, the bunching and shortening of leaves and branchlets and death of branches in the case of the first two species and the lanky form of Spike in the last species. Red spider has been found in company with grey bug (*Monophlebus*), *Psyllidae* and *Dactylopius* species.

In Vellore, red spider was found swarming on *Zizyphus oenoplia* by itself, whilst on the same species spiked and unspiked in the Denkanikotta Range it has been found by itself and in company with grey bug (*Monophlebus* species).

On *Dodonæa* at Jowlagiri and Aiyur, it is found accompanied by *Dactylopius* species and *Psylla* species, as well as by itself.

On *Cipadessa* it is found by itself.

Up to the present, I cannot make out how it reproduces itself and what gives rise to the first stage, the minute transparent globules. Perhaps it matures with the fallen leaf and remains dormant in the earth. In its adult stage, it is very lively and, no doubt, spreads quickly.

I have failed so far, to collect specimens. Dried specimens are out of the question whilst in spirits they lose colour and appear to be dissolved.

As regards its effect on the plants it attacks, I may mention that there

was no Spike to be seen at Aiyur on the numerous *Cipadessa* bushes last year from June to November 1916. In June I introduced the caterpillars of the Atlas moth), brought on branches from near Denkanikotta, and again in October 1916, so that I had opportunity to carefully examine these bushes. In June 1917, six are showing spike-like growth and many more have the frosted appearance and are covered with red spider.

At Jowlagiri, I marked five or six bushes of *Argyreia cuneata* in April 1917 that were swarming with red spider and were then not showing any signs of spike-like growth. I visited these bushes in June last, when to my surprise, I found one of the bushes completely spiked and nearly three-fourths dead, whilst the remaining bushes all showed Spike more or less conspicuously.

Also in the case of *Cipadessa*, I had marked several bushes covered with red spider on the path from Denkanikotta to Jowlagiri last year in June and October 1916. In June of this year all these bushes are spiked. A patch of *Dodonæa viscosa* was discovered near Jowlagiri bungalow in April 1917 swarming with red spider and *Psylla* species. No Spike of any form was to be met with round about here up to this month, yet in June 1917, the lanky form of Spike had appeared in six of these bushes. Experiments are now being undertaken with red spider placed on plants covered over with net.

(*b*) *Grey bug* (*Monophlebus* species, family *Coccidæ*) has a remarkable life history, as shown by Maxwell Lefroy (*vide* Memoirs of the Department of Agriculture, Vol. II, pages 111–117.) It is a very widespread bug having been found at Mount Stuart by Mr. Wilson and by the Conservator in the spiked area on the Pachamalais also in the Kollegal Forest District by me in 1904-06 and is found on a large number of species, spiked and unspiked. At a certain stage (3rd moult) it becomes very active and then after a period it disappears, and only recently it has been found that it enters the soil and remains there dormant between October and March. During this period it apparently oviposits, as shewn by experiment No. 1, Denkanikota. Its appearance synchronises with the first burst of new buds and foliage which depends on the rainfall in the hot weather and it feeds principally on the flower buds and young succulent shoots and under sides of leaves, sucking the sap. It is a great wanderer and works its way out of netting as I have found with my experiments. I have not been able to follow its correct life history so far.

In young leaves of *Terminalia tomentosa*, *Terminalia chebula* and *Pterocarpus marsupium*, it causes a very marked curling and crinkling of the leaves and a modification of them. In sandal, so far, it has given rise to the characteristic crinkling of the leaves and a suspension of new growth for a remarkable length of time.

In the case of another experiment conducted at Denkanikotta, six of these grey bugs were put on to a healthy sandal plant in October 1916. The bugs after a time, disappeared, but in January 1917, the tree experimented on suddenly shed its leaves and by the end of February both its host (a croton) and the sandal tree died. It was at first presumed that the tree died from want of water but this supposition proved to be incorrect. The sandal plant was carefully taken out of the soil and washed when two marks were seen under the roots where two bugs had apparently hybernated. Two young bugs were found in the net on small creeper seedlings; the remainder must have escaped as there was nothing for them to live upon.

Further experiments are being carried on, but it will be interesting

to record that a small *Argyreia cuneata* bush near the Aiyur Forest bungalow was found with grey bug on 24th May 1916. This plant showed Spike on *one branch alone* in April 1917 and is now (July 1917) dead whilst the rest of the tree has so far no signs of more Spike. The tree was not covered over with netting and red spider introduced in October 1916 is within a couple of yards of it.

(*c*) *Dactylopius* species has been found above ground on spiked and unspiked sandal, *Dodonea* and *Jatropha gossipyformis* in company with red spider and *Psylla* species. It is not yet possible to state what the result of attack appears like. This bug is in appearance like the picture of *Dactylopius citrii*. It has two long processes at its anal end, white in colour. It is found singly and in small colonies on the tree above ground. Experiments are being carried out at Aiyur.

(*d*) *Stellate bug*, (*Icerya* species) has been found on *Olea cuspidata* round about Jowlagiri in April in company with red spider; recently one was found crawling about on a marked sandal tree. All the plants on which this bug has been found, are exhibiting marked spike-like growth. Specimens of the plant were sent to Dr. Coleman in April 1917 and he found starch accumulation. It is also met with on a species of *Jasminum*. This insect is in appearance, more or less, flat, about $\frac{1}{4}''$ in diameter, snow-white with long radiating snow-white filaments which give it somewhat a circular shape. The body of the bug with the white powder removed is pale yellowish pink in colour. One was found by me in October 1916 floating in the air, being carried by wind in the Parathavadi Bail spiked area.

(*e*) *Denkanikota bug*, (*Icerya* species).—This species is distinct from the *Stellate* bug. It was originally found on sandal in a suspicious sandal area near Jowlagiri. The sandal attacked had a curious yellowish appearance of the leaves. The life history of this bug is a remarkable one, much more so than that of the grey bug. Six gravid bugs were placed on a sandal tree at Denkanikotta in October 1916 and the tree covered over with netting. The original six bugs gave off tiny reddish bugs *without laying eggs*; or possibly, the eggs hatched as soon as they were protruded by the mother, under the white cottony growth. They increased rapidly and by March 1917, three generations had been produced apparently without the help of the male. Early in February, three-fourths of the leaves of the tree were covered with these bugs and an average showed seven large bugs to the leaf. In April, the bugs had increased to an average of 112 bugs to the leaf and still no male was visible. In March, the tree began to wither from the top. In April, the top portions had died and on shaking the tree *every leaf fell off*. The bugs were removed and the result is being watched. Since then the tree has put forth new leaves and a large percentage of the leaves has developed, in verticils of threes and fours,—several double leaves. No such abnormal growth was found on the tree prior to the placing of these bugs. These abnormal leaves have been preserved in spirits for reference. The remaining growth does not appear to be very healthy and the stem is hide-bound. In appearance this bug is somewhat like the figure of *Icerya minor* depicted by Maxwell Lefroy in his plate, but it has a much longer growth of white cottony matter at its anal end. A large number of small bugs, very feathery in appearance, attached themselves on the under sides of leaves along the mid ribs and covered themselves with a mass of white cottony substance. Within the last week one lot of these placed in a tube turned into males, somewhat like the original male of *Icerya minor* depicted on the same plate, but the

wings are a dark neutral tint. Many of these males must have hatched out before, but were not noticed under the net owing to their small size.

This species of bug is attacked by the larvæ of the *Lycœnid* butterfly, *Spalgis epius*, and also by a tiny hymonopterous fly. It is also devoured by the tailor bird.

Two of these bugs were taken by me to Vellore in August 1916 and placed on a healthy sandal tree and in September 1916 several bugs were found on the tree. In November and December 1916 two or three " swollen " bugs were found on the same tree that differed in colour and were smaller in size, the colour being a light yellow with darker yellow at the anal end instead of the white flocculent growth. In my opinion, it was merely a seasonal form as a similar bug was found by me at Denkanikota in Mrach-April 1917. This bug was parasitised on by a smaller lady-bird beetle larva and many bugs are destroyed by these larvæ.

(*f*) *Walkeriana cinerea.*—A large conspicuous bug in its adult stage. It was first discovered at Denkanikota on a sandal tree that was remarked on by Mr. C. D. McCarthy in 1913 as having peculiar growth. Its life history appears to be still more remarkable than the Denkanikota bug. Live bugs are given off by the gravid female and the young bugs are quite distinct in appearance from the young of other bugs. Each bug, on emergence, has three rows of long single hairs sticking up and by this means it seems to be blown about by wind. The life history is not yet worked out. A remarkable point about the damage the bug does to sandal, has been ascertained within the last nine months. The branches and branchlets on which it feeds die. This was ascertained by tying red string to the branches which the bug was found attacking. It is surmised that this insect may be the cause of numerous dead branches found on sandal in suspicious areas.

This bug has been found on *Dodonaea viscosa* also, and may eventually be found on many more species. Experiments with this bug placed on sandal under netting are being undertaken.

(*g*) *Psylla species* :—This belongs to the family *Psyllidæ* allied to *Coccidæ*. It was found originally at Royakotta in the third week of June 1916 on *Cassia fistula*, on which it undoubtedly produced a spike-like appearance, the branchlets dying down to the main stem. An *Albizzia lobbek* sapling, situated in my compound in Vellore developed spike-like growth in the month of November 1916 during my absence. I took it at first to be due to grey bug, as grey bug was found on a sandal overtopping it and I had introduced this grey bug. But in February 1917, I found another *Albizzia lobbek*, about a mile south of my bungalow opposite the Police Mess (at Vellore) similarly attacked, and on examination, I found it swarming with this *Psylla* species and subsequently it was found in other localities in Vellore. One branch covered with this insect was brought away and tied to a healthy *Albizzia lobbek* in my compound about ten yards away from the first tree. On the 6th February 1917, a small piece of the tip of the branch tied to the healthy tree broke off and this small piece about 2" long was pinned to another healthy *Albizzia* about 25 yards away.

On my return to Vellore on 12th March both the healthy *Albizzias* were showing signs of spike-like growth on the new leaves and were covered with *Psylla*. By the end of the first week in May 1916, this spike-like growth was very conspicuous. The branches of the original *Albizzia* that were attacked in November died and the new growth proceeding from the stem below them was spiked. Mr. K. R. Venkatramana Ayyar,

District Forest Officer, South Vellore, had personally seen this experiment in February and again at the end of March. A sample of the spike-like growth was sent to Dr. Coleman but he could find no starch deposits in the leaves or tissues. A further sample from the same tree will be sent to him as early as possible.

It is noticeable that Mr. Bainbrigge Fletcher on plate No. XLVII in his book on " Some South Indian Insects " has actually pictured Spike in a species of indigo caused either by this or some allied insect.

Species on which Psylla has been found.—

1. *Cassia fistula.*
2. *Albizzia lobbek.*
3. *Tephrosia indica.*
4. *Cassia auriculata.*
5. *Strychnos potatorum* (the species of *Psylla* found is doubtful and has to be identified).
6. *Dodonaea viscosa.*

The *Psylla* found on *Dodonaea* appears to be different from the *Psylla* found on the first four species and I am doubtful about the species found on No. 5 (*Strychnos.*) This last will be referred to further on under green scale, page 12. I have taken specimens for identification.

Psylla appears to me to be a hot weather insect, for it has so far been found from February to end of May. There seem to be two species, one with ruby coloured eyes and a second found on *Dodonaea* which has not the ruby coloured eyes and is much more yellow in colour in the larval and pupal and perfect stages.

This insect is very small in its young stage and is just visible when it commences to pupate. It attacks the young shoots, leaves and stems.

(*h*) *Eurybrachys tomentosa.*—The life history of this insect has been worked out and is attached to this report. It feeds on sandal and numerous other plants. The sandal tree experimented upon is being watched for any peculiarity in its future growth. This plant was, however, damaged by cattle and though it has put on new growth, there is no change observable up to date.

(*i*) *Messena sinuata* is another genus allied to *Eurybrachys.* Its life history is similar to that of *Eurybrachys* and its larvæ and pupæ are very like that of *Eurybrachys*, but a little larger and of slightly different colour. It has been found on sandal and *Albizzia amara.*

(*j*) *Pulastya acutipennis.*—This handsome " jumper " has been found on Sandal in its larval and pupal stages. It feeds on the roots and young parts of sandal and several other species. Its life history as well as its effect on sandal, has still to be worked out.

(*k*) *Flata* species. (*l*) *Melicharia lutescens.*—These two are similar to *Pulastya acutipennis* and behave in the same way and have been found on sandal in their larval and pupal stages feeding on the succulent parts and roots. Their effect on sandal has still to be worked out carefully. They have, however, not been met with this year since March.

(*m*) *Black scale or Brown scale.*—Two trees badly infected by this scale have been marked at Jowlagiri and are kept under observation. It was interesting to find a small flower-pecker bird known as the " White-eye " destroying them wholesale. I watched the bird for about five minutes, within a range of three yards, and it ate up all the scales on a branch and cleared the branch for about the length of one foot.

I also found what I took at first to be a giant brown scale amongst these, but on examination, I found the top covering to be made of silk. Inside

was a larva, which I took to be that a lady-bird. I however subsequently bred these out successfully and they turned into whitish moths of the family *Eublemma* (*Noctuidae*). Myriads of these larvæ were found and I observed that they were not damaged by the large black ant that accompanies the brown scale insects. The scale insect was eaten by means of a hole made on its side and the empty shell left *in situ*. In some cases the shells of the scale were attached to the covering of the larvæ and it looked as if two or three scale insects had amalgamated.

(*n*) *Green scale* :—I am not sure if this is the notorious *green scale* of coffee shade tree. It has been met with on sandal and on several other species of trees, especially on *Strychnos nux vomica*. One tree of this species is situated within ten yards of experiment No. 1, Aiyur (see para 8 page *infra*). In November 1916, it was discovered that almost one fourth of the tree was dry and it looked as if these portions had been burnt. Not a leaf remained on the twigs. On examination a *white scale* was found, *i.e.*, a *scale* could be seen, but its extremity was a languish white mass in which there were minute eggs. In March 1917, this tree put out young leaves and growth and on it was found what I took to be a *Psylla* the same as that found on *Dodonaea* in the same month. Later, it was found that the larger (there were two sizes yellowish in colour with wing cases visible) attached itself to a part of the tree and began to develop the whitish growth. Subsequently in April-May 1917, it was seen to develop into the original *white scale*. This is not the *green scale* but the *Pulvinaria*. In June last, white egg-masses gave off tiny green scale that exactly resemble the *green scales*. If this is really the *green scale*, I have made a discovery as the male of this scale has never been found. I have specimens of these for identification.

(*o*) *Conical scale* :—This has been found, not by any means in large numbers, on sandal and other species and it may turn out to be " Black or Brown " scale ; the shape of the shell, however, differs.

(*p*) *White scale* :—This may yet turn out to be the *green scale* in its adult stage when it forms the white egg-mass, or ovisac.

These scale insects must do some damage by sucking the juices and they have to be experimented with.

(*q*) *Ricania fenestrata* :—The female of this jumper lays its eggs in *the green cuticle* of young sandal branchlets. It is being constantly found and it has to be experimented with and its damages, if any, ascertained.

(*r*) *Black looper caterpillar* :—I have bred this out and know the moth but have not my book of reference with me to give its name. The larva appears to be merely a leaf-defoliator and it does not appear to be the cause of or carrier of Spike.

(*s*) The two species of small whitish beetles appear to be also merely defoliators and I think can be safely put aside.

NOTE ON THE HISTORY OF SANDAL SPIKE IN MYSORE.

By Mr. M. G. Rama Rao, Conservator of Forests in Mysore.

Historical sketch :—The disease was first brought to the notice of the public by Mr. McCarthy in 1898-99 as a serious disease threatening the existence of sandal in its natural home. Prior to this, the disease must have existed and from available records it is just possible that the diseased tree might even have been suspected to be a variety of sandal.* Since then, the seriousness of the disease has been brought home to us by the almost wholesale death of an enormous number of affected trees and by the rapid spread of the disease over localities far away from its original location.

Up till 1902 the nature of the disease was being investigated by the local Forest Officers, when, with the help of the Cryptogamic Botanist of the Government of India and the Botanist to the Government of Madras and the Agricultural Chemist of Mysore, some experiments were carried out in a plantation near Hosur-Marigudi in the Hunsur Taluk, but these came to nothing.

Description of the disease :—The nature of the disease as exhibited by external appearance and the internal structure of the diseased parts are so well-known that it needs no description, but it may be noted here that in Mysore it is seen in three different types :—

1. Lanky form,
2. The normal Spike with
   (*a*) normal coloured leaves ;
   (*b*) copper-coloured leaves ; and
3. The weeping type.

The first two forms as observed in Mysore are the same as those described by Mr. P. M. Lushington. The last one so far as I know has not yet been recorded. The branchlets become pendulous and the leaves get crowded at the end of the branchlets.

The leaves are of the usual spiked type except perhaps that they are a bit longer but they are beautifully golden yellow in colour. It is worth investigating further.

Nature of the tracts in which the disease is found :—From general observations made in the field, the disease is found to exist in all localities where sandal is growing from the very richest to the very poorest sandal areas. It has been discovered in the best of garden soils where the tree attains magnificient dimensions in a healthy condition while it is also noticed in isolated trees in the midst of dry cultivation and also in poor dry localities where sandal was introduced artificially as in some of our plantations. Consequently, it is also found in localities where all sorts of external factors have had their free scope, *i.e.*, fire, drought, etc.

From this one has to conclude that no external factor such as fire or

* Mr. H. Srinivasa Rao observed this in August 1896 and Mr. P. M. Lushington has referred to it in his "Notes on the Sandal-Tree."

drought or other damage can be a direct cause of the disease, but, at best, it may be only considered as a predisposing factor.

Extent of its occurrence and the mode of its spread :—After an exploration of the sandal tract in the Hassan and Mysore Districts, it was found out by Mr. Muthannah in 1902-03 that the disease was restricted to isolated tracts here and there in the Hunsur Taluk and parts of the Mysore and Heggaddevankote Taluks adjoining Hunsur.

Since there was a strong opinion that the disease was an infectious one based on no sort of scientific data, the Mysore Government perforce accepted the stringent measures adopted by Coorg for the eradication of the disease by uprootals and isolations. Since then, the disease has been spreading eastwards and southwards. By 1904-05 the disease had spread over the whole of the Hunsur and *maidan* parts of Heggeddevankote Taluks and had made its appearance in Chamrajnagar and Gundlupet Taluks. It was even noticed in the Hassan District bordering on Hunsur and Coorg, but the progress was noticed to be very slow towards the north. In 1905-06 there was no further progress to any new taluks. Same was the case in 1906-07 and 1907-08. In 1908-09 the disease was noticed in the Basavanbetta Forest of the Bangalore District, and at the present day it is even found within six miles west of Bangalore. In the Hassan District, the disease has not made any appreciable progress in its spread.

From this it will be seen that the disease has been spreading eastwards from the localities where it was first noticed. The Kolar, Tumkur, Chitaldrug, Kadur and Shimoga Districts are yet free from the disease.

Experimental operations conducted in Mysore and their results :—Some experiments on the following lines were conducted so far back as 1903 in the affected parts of Hunsur to study the nature and origin of the disease :—

(1) One perfectly healthy tree standing in the open was girdled in order to watch the formation of new shoots and leaves and changes in their appearance and size with no appearance of Spike on it.

(2) One perfectly healthy tree standing in the open had all lateral roots cut out and the excavation filled up with stones and earth but no Spike appeared.

(3) One perfectly healthy tree standing under shelter was similarly treated but no Spike appeared.

(4) The branch or branches of some spiked trees at the earliest were sawn off from the main stem with no preventible results of Spike later on.

(5) Some spiked trees were coppiced ; the shoots later on developed Spike.

Measures adopted to eradicate the disease and their results :—The only method adopted is the uprootal of all affected trees wherever they are found, isolated or in small patches, and the isolation of affected tracts by clearing all sandal growth in a strip of hundred yards all round the affected patch. In all cases of uprootal, the wood was burnt except heartwood containing stems which were taken to sandal koties. In all, since 1903-04 we have uprooted about 7 lakhs of affected trees and plants but I must say, without any beneficial result in checking the further spread of the disease. Unless and until we know the mode by which and the parts of the tree through which infection is carried, uprootal operations are found to be of no value. But on the other hand, we may be exterminating sandal by wholesale uprootals from areas occupied by that valuable tree at present.

General observations.—From the results so far arrived at by the recent experiments conducted by Dr. Coleman and the more or less regular

progress of the disease from Coorg-Mysore frontier eastwards, I am inclined to the opinion that the disease is an infectious one. I cannot attribute the spread of the disease to any particular external atmospheric influence or other factor but the principal points that I wish to bring to the notice of the Conference are :—

(1) The large number of trees affected during the April flush of leaves;

(2) Where the disease first puts in its appearance in undulating country, the trees first affected are those growing on exposed knolls or ridges with hard and strong soil;

(3) A considerable quantity of roughly prepared wood from the spiked trees has been brought into Hunsur and Seringapatam koties for further preparations and sale. Here the sandal trees existing in the koti compounds are very healthy and show no signs of Spike.

Suggestions for our future work.—Before any investigation of Spike disease is undertaken, I would suggest that the question of root parasitism of sandal be first investigated and definitely solved, as it is a subject of pre-eminent importance so far as sandal is concerned. During this investigation, I dare say, a considerable amount of preliminary ground will be cleared which may be of immense use in the solution of the disease.

(2) I am not inclined to recommend uprootals until we know something more definitely about the medium of infection.

(3) Besides the elaborate experiments carried on by Dr. Coleman, I would suggest the formulation of a set of experiments that may be carried on in several localities by Forest Officers in such manner as may be considered suitable either towards the solution of the life history of the tree or of the disease itself.

(4) A regular survey of the spread of the disease should be conducted in July, August, November and December.

NOTE.—The map supplied to the Conference, showing Sandal Spike area in Mysore will be found in the appendix.

EXPERIMENTS TO TEST THE EFFECT OF REMOVING LANTANA ON THE INCIDENCE OF SPIKE ATTACKS.

By H. Tireman, Deputy Conservator of Forests, Coorg.

Locality :—Chinnanhalli near Fraserpet, Coorg. A low stony ridge running roughly north and south covered with lantana containing a large number of stunted badly grown sandal. No fires have occured since 1910 and probably not for several years previous to that (Mr. McCarthy may probably remember whether fires occurred in his time or not).

Plots I and IV, 8 and 5·3 acres respectively, have been left as they were, nothing being done except the uprootal of spiked sandal.

In Plot II (10·5 acres) lantana was uprooted in 1911 and the area has since been kept clear of this weed.

In Plot III (6·3 acres) the lantana was uprooted in 1912. The accompanying statement shows the number of trees per acre uprooted each year and the percentage of number uprooted to the number per acre existing in 1911. In the case of Plot I, owing to some carelessness on the part of a subordinate, (I cannot call to mind the details) I had to regard as useless the figures obtained prior to 1915. The number of trees per acre in this case is the number found on the ground in 1915.

It is not certain that all the sandal trees uprooted were spiked trees. Trees dying from other causes are included among the number uprooted. These, however, from a very small proportion of the total uprooted.

14. The results of this experiment so far have been as shown in the next page :—

Removal of Lantana.

Plot number	Area in [illegible]	Lantana	Number of trees per acre in 1911	Number of diseased trees per acre uprooted and percentage of trees uprooted to number of trees in 1911														Remarks
				1910-11		1911-12		1912-13		1913-14		1914-15		1915-16		1916-17		
				Number	Per cent.	Number	Per cent.	Number	Per cent.	Number	Per cent.	Number	Per cent.	Number	Per cent.	Number	Per cent.	
I	8	Not uprooted.	223 in (1915)	..	..	..	..	..	..	..	..	..	..	63	28	56	26	Per cent to No. of trees in 1915.
IV	5.3		721	..	..	57	7	132	18	132	18	162	22	75	10	37	5	
II	10.5	Uprooted in 1911 ..	568	33	6	20	3	8	1	3	5	12	2	10	2	17	3	Do do
III	6.3	Do 1912 ..	404	..	..	39	10	19	5	2	5	14	4	10	2	13	3	

NOTES ON SPIKE DISEASE.

By C. D. McCarthy, Conservator of Forests, Madras.

Fire in itself cannot induce an attack of Spike. Its action in causing an apparent outbreak of the disease is simply due to stimulation of the circulation of those trees which have poisoned sap already within them although the outward symptoms have not yet appeared. This is exactly similar to the apparent outbreak of the disease at the commencement of each growing season. As it happens, the fire season is almost coincident with the growing season of sandal, so that the tree is ready to respond to such stimulation. It is probable that if the infected trees in Dr. Coleman's plot on which Spike grafts are established were subjected to a suitable scorching by fire the infection of the whole tree would be considerably hastened.

Lantana :—Were it not for its liability to fires, lantana is about the best host and protector of sandal. If lantana has any effect on the spread of Spike Disease of which personally I am very doubtful, it is probably in an extremely indirect manner. That it has no infective property is perfectly certain because sandal has been growing and flurishing in it for generations. In Kollegal and North Coimbatore there are a dozen isolated sandal areas extending to thousands of acres in which new infections of the disease have occured and in which the whole of the sandal has been swept away, where not a single lantana plant existed. On the other hand, there are perfectly healthy sandal areas in which the species is associated with heavy lantana. If lantana possesses any infective qualities through the diseased root contacts or anything else, how is it that the Spike Disease did not break out in the lantana areas of Coorg and Mysore dozens of years ago ?

Mr. Tireman's tables showing the effect of lantana clearing in diminishing the number of attacked trees are no doubt remarkable, but they cannot nullify these facts. It is very likely that the mere clearing had some beneficial effect apart from the removal of the lantana.

Spread of infection :—We must look for some cause other than haustorial contact. The manner in which the disease extends within an infected area across distances too wide for inter-root connection proves it. Personally, I think that when the impossibility of infection by root contact has been established in so many cases, this theory even if it is proved by experiment will not be the chief source of infection. I am even sceptical that the disease can be contracted by root contact. I have from the very beginning maintained that the Spike in *Zizyphus* which is closely associated with sandal in all sandal areas is identical with the disease in sandal ; and I have for some time been convinced that the main, if not the only source of infection, is above ground. Long before I left Coorg I noticed that within the worst infected areas around Fraserpet and Periyapatna, young plants coming up under dense lantana sufficient to protect their crowns from aerial infection were invariably immune from attacks, whereas all around them the plants which had just broken out of the lantana were attacked. As before, I believe that within a sandal area the disease is

spread from spiked sandal, *Zizyphus* and perhaps other species which have since been observed to suffer from a similar disease, and that the active agent whatever it is, is only capable of carrying infection over a short space of ground. This opinion is based upon the *gradual* spread of infection *within* a sandal area.

As regards the infection of sandal areas distant from one another, I think it is carried from spiked *Zizyphus* and other species that have already spread to those areas. *Zizyphus* is more susceptible to Spike even than sandal is. The infection and spread of Spike is less active in zones of heavy rainfall. The most likely agent of infection, so far as our information goes up to the present, seems to be some bug or insect with a short radius of activity.

Preventive measures :—From this point of view, in my opinion, the most important discovery made so far is that of Dr. Coleman showing that the infection is in the trees for some considerable period before the appearance of outward symptoms. This is even more important than the grafting successes ; because, though the proof of this was wanting until he took up his experiments, it was practically obvious and certain that Spike is an infectious disease. The efficacy of clearing *in front of* a line of attack is based upon *the fact* now proved that the disease is in the tree some time before the outward symptoms appear, and on *the theory* that the agent of infection from tree to tree and from species to species has a very limited area of mobility. Even to this time the only place where the clearing theory has been effectively carried out is in Corog and there it has checked the extension of the disease on the line selected for it for 16 years. The clearing was bungled at Jowlagiri and lately again in Kollegal. The clearing need not be in lines. The measure consists in the removal of all *apparently healthy* sandal, *Zizyphus* and other spike-susceptible species in front of the line of Spike attack. The width of the clearing should be about $\frac{1}{8}$ to $\frac{1}{4}$ mile, and the wider, the safer; and its theory is that it removes all trees and plants which have already the infection within them though not visibly so, and it creates a space too wide to be crossed by the agent from the visibly diseased line to the healthy area beyond the clearing.

Clearing is absolutely futile *within* an attacked area. For six or eight years, all visible spiked sandal was removed within the diseased area north of the Fish River in Coorg. The work was so throughly done by a special staff throughout that period that repeated inspections showed that no visibly spiked trees were to be seen and any observer would have said that there was no Spike in the areas. Yet, from year to year there was no diminution in the number of spiked trees attacked and removed ; and this is now explained by Dr. Coleman's discovery referred to above.

Mr. Hearsey's preliminary form of Spike called the lanky form :—I have now seen specimens of this. It is not Spike at all in my opinion. I have seen it before in sandal and in coffee. It is a temporary phenomenon to which individual trees enjoying from their favourable position strong luxuriant growth, are subject if suddenly placed under exceptional weather conditions inducing a great acceleration of growth. The symptoms are :— abnormal lengthening and a ribbed appearance of the internodes, enlargement of the nodes, a disturbance of the opposite location of the leaves and a considerable diminution in the width and size of the leaves giving them a pointed appearance. Such a tree may contract Spike immediately afterwards just like any other. But the lanky growth is not Spike, much less should it be styled a preliminary form of Spike, for this appearance is an extremely rare manifestation in sandal if at all ; and more so amongst trees which have contracted the disease.

FIELD INVESTIGATION OF SPIKE DISEASE IN SANDAL ON THE KOLLIMALAI HILLS.

By Rao Sahib M. Rama Rao, Special Forest Officer, Mysore.

The sandal occurs in patches on the Kollimalais as indicated in diagonal lines on the accompanying sketch. The several species of plants with which it is associated are given in the list appended. The altitudinal limits of its occurence are between 1,500′ and 4,200′.

In the middle of 1912, Spike Disease was reported to be absent on these hills and so also lantana. But in April 1914, the disease was reported to have attacked a young sandal sapling in the middle of Jambuthu Reserve on the western slopes. In October following, the District Forest Officer found there a number of young trees attacked and several plants dead, and thought that the disease had been there for some time previously. All the diseased living trees which numbered 78 were uprooted in May 1915, when the local Ranger reported that the disease had not spread to any other part of the hills. The girth measurements of the uprooted trees showed that the disease had attacked plants of $\frac{1}{2}$″ to 12″ girth, there having been no bigger trees in that area. The spiked areas are indicated in cross lines on the map and the first observed spot is marked *A*.

In July 1915 I inspected this area and found the disease had spread a little higher up the brow of the plateau (marked *B* on the map) with an unaffected gap between it and the patch *A*. On the eastern brow of the hills about 8 miles east of the above spiked area, I discovered early in August 1915 a number of fairly large sized trees as well as saplings spiked and many saplings standing dead. This area is near Sellipatti and is marked *C* on the map. From their appearance I thought that the trees had been attacked much earlier than those in the Jambuthu area, because their leaves were much narrower and smaller, closer and more reddish green than those of the diseased trees in the Jambuthu Reserve and there were besides a much larger number of dead trees also. In the latter area, the affected leaves were thinner, longer, deeper green and somewhat more distant from each other and the branchlets themselves longer and more drooping. Whether these differences were due to differences in the external conditions of growth obtaining in the two localities as set forth below or to any peculiarites of the disease itself is a question that remains to be investigated. On enquiry of the villagers of Sellipatti living quite close to the affected trees as to when they noticed it, thay stated that it first appeared *three years previously*. Mr. P. M. Lushington, Conservator of Forests, inspected both the areas in January 1916 and thought that it was very probably so. Again, saplings in another patch close to *C* and separated by a low hill ridge were found diseased. This is marked *D* on the map. Between *A* and *B*, *C* and *D*, there were sandal trees which bore no signs of the disease and were quite healthy-looking. The numerous sandal patches between Jambuthu and Sellipatti were carefully gone over first by a trained Ranger, a few months afterwards by myself, and five months later by Mr. P. M. Lushington and myself to see if Spike had appeared in any of them, but we could find none.

The external conditions of growth observed in the Jambuthu and Sellipatti spiked areas are as noted below :—

External conditions	Jambuthu	Sellipatti
(*a*) Aspect	Western and therefore cool.	Eastern and warm.
(*b*) Altitude	2,500′ to 3,500′ ..	3,200′ to 3,400′.
(*c*) Associates.. ..	Young and dense and semi-evergreen.	Open and scrubby evergreen.
(*d*) Soil	Reddish loam mixed with stones and rocky outcrops.	Dark loam with stones and boulders.
(*e*) Sandal	Mostly saplings and poles, but hardly any seedlings.	Fairly large trees and saplings and abundance of seedlings.
(*f*) Fires	Immune from fires being semi-evergreen.	Being over-grazed always, no fires had occured or could occur.
(*g*) Other diseased species. .	*Zizyphus oenoplia*, *Pterolobium indicum*, *Dodonæa viscosa* and *Jasminum* sp. occur but no root-attachments with sandal found.	Same species found but none close to affected trees, nor any root-attachments found.
(*h*) Proximity of other parasitic plants.	*Cansjera rheedii* very commonly found but no root-attachments with sandal; *Viscum verruculosum* on a few sandal plants which were unspiked.	*Cansjera* very abundant but no root-attachments found. *Loranthus tomentosus* had attacked a healthy tree; *Viscum verruculosum* was found on a few unspiked sandal trees.
(*i*) Healthy sandal ..	In close proximity to spiked trees many healthy sandal plants were found but without root-connections with diseased trees, though their roots crossed each other.	Same was the case here too.

In both the spike-affected localities of Jambuthu and Sellipatti, the root systems of a number of spiked trees and a few healthy ones in the neighbourhood were examined after carefully dissecting the earth round them, and the results of examination are noted below :—

(1) The roots and rootlets of host plants in contact with or close to sandal roots were, generally speaking, healthy.

(2) The root ends of spiked trees were in all cases dead.

(3) Haustoria were dead in almost all cases, but in a few, live ones were found on roots of neighbouring host plants; but these might have been formed by other healthy sandal plants or by the *Cansjera*. Actual attachments could not be traced.

(4) In spiked trees, new rootlets were not produced as a general rule, but in a few cases, root-fibrils had been formed; but they were blanched, weak and withered, the withering commencing at the tips. Such fibril-like rootlets had not formed any connection with neighbouring roots of other plants.

(5) Most of the root ends of a sickly-looking sandal seedling which was not spiked were not dead and live root-attachments with other roots

were found with live haustoria, even though the seedling had been badly attacked by *Viscum verruculosum*.

(6) The roots of unaffected sandal saplings and seedlings in very close proximity to spiked trees were healthy-looking with the root ends and haustorial connections alive and vigorous, although some of them crossed roots of spiked trees.

(7) In Sellipatti area the spiked branchlets were short and their ends dead, while similar branchlets in Jambuthu were much longer and drooping.

(8) No flowers were found on spiked branchlets in both localities. But in partially spiked trees, some branchlets bore normal leaves, flowers and even fruit, and to all outward appearance were unaffected.

(9) In Jambuthu, saplings which looked healthy in July were found spiked later and died in the following January; whereas in the Sellipatti area the same was the case with saplings, but older trees found spiked early in August were in the same condition externally in January and a few died only in April, thus seeming to indicate that older spiked trees take longer to be killed than younger trees.

(10) A young sandal tree had one branch spiked, while the other which was larger of the two branches had normal leaves and branchlets. The lateral root vertically below the spiked branch had its root ends and haustoria dead, while the root below the other branch and diametrically opposite to the diseased root was much longer, had more tertiary roots and numerous rootlets and living haustoria with a number of attachments. In this case, where did the disease first attack the tree—whether in the crown or in the diseased root? If the disease is induced by a virus, and if the latter circulated in the sap, why were not the other branch and the root below attacked simultaneously? Again, does the crude sap sent up by a root or the elaborated sap sent down by a branch circulate only on that side of a tree on which the root or branch exists? These questions have to be elucidated by a physiologist.

(11) Numerous young and healthy sandal rootlets were examined by me with a strong lens, but in no case were root hairs found, whereas on rootlets of host plants, they were abundant.

(12) Among the spiked trees examined, no damage by insects or fungi was noticed on their roots or stems and branches. In one case, there were rose beetles and larvæ and in another mycelia of a fungus close to the roots, but these latter bear no traces of attack by either.

(13) A few vigorous and quite healthy-looking sandal saplings a little lower down the spiked areas in the Jambuthu Reserve shed a number of young leaves of the new flush when the trees were shaken, while other saplings did not do so. This was in January 1916 when the Conservator was present, and he thought that this phenomenon was remarkable. On examining the base of the petioles of the shed leaves with a lens, I found that the fibro-vascular bundles were disorganized and weakened, while the basal ends of petioles of similar leaves plucked off healthy twigs of other saplings did not exhibit this weakening of the fibres. One of the saplings was placed under observation and it was found quite normal and healthy in May 1916, and its root ends were also healthy and had formed a number of attachments with other roots. This tree was some months later reported to have died but whether its death was the result of any disease of which the leaf shedding was an external symptom, or of the disturbance of its roots caused by digging round them for examination could not be determined.

(14) In almost all cases of withering of rootlets of spiked sandal, it was found that the withering commenced at the very tips and gradually extended upwards.

Our investigations on the Kollimalais tend to confirm most of the observations that had been previously made and recorded by Dr. Barber in his Report on Spike Disease submitted to the Board of Revenue, Madras, in 1902.

Dr. Coleman's grafting experiments tend to show that the disease is communicable from tree to tree when in close organic contact, but they have not yet reached the stage of explaining the spread of the disease in nature from one area to another with an intervening unaffected space of many miles between. Thus for instance, the nearest previously known spiked area from the Kollimalais was 80 miles away. How could the disease have skipped over such a long distance and communicated to the sandal trees in two distant patches on these hills ? How could it have traversed from Sellipatti to Jambuthu, eight miles apart, without affecting any sandal areas lying between them ?

The disease was first discovered in Coorg in 1899. Mr. P. M. Lushington found a number of trees dead at Punachi in Coimbatore in 1898 and this was subsequently believed to be due to Spike. If this belief were correct, how could the disease have jumped over such an enormous distance, without appearing in the intervening vast area of sandal tracts ? Even in Dr. Coleman's experimental plot at Bangalore, sandal plants which are not operated on with the grafting experiments are quite healthy-looking and unaffected in spite of the existence of introduced Spike plants in their neighbourhood during the last *three* years.

These facts lead one to be sceptical as to the contagious or infectious nature of the disease and to believe that, after all, it may be endemic and spontaneous. Meanwhile, we must patiently wait and see what further developments Dr. Coleman's experiments at Bangalore and Mr. Hearsey's experiments in connection with his insect theory will lead to.

APPENDIX B.

List of Host-plants of Sandal trees in the 'Spiked' areas on the Kolimalais.

Serial number	Botanical name	Vernacular name	Remarks
1	Cansjera rheedii ..	Vanda-thuluru ..	Sparingly attacked by a root-parasite—probably sandal.
2	Anogeissus latifolia.	Namai	Largely attacked by root-parasite—sandal or *Cansjera*.
3	Acacia pennata ..	Seengai	Largely attacked by sandal.
4	Vitis pedata ..	....	....
5	Cipadessa fruticosa.	Pena sedi	....
6	Flueggea leucopyrus.	Vellai-pulai	....
7	Albizzia odoratissima.	Selai-usilai	....
8	Erycibe paniculata.	Onankodi	....
9	Phyllanthus emblica.	Nelli	....
10	Mallotus philippinensis.	Gundansolai ..	Sparingly attacked by sandal roots.
11	Mallotus lawii ..	Solai-karupichchi ..	....
12	Murraya exotica ..	Vellari	....
13	Clausena indica ..	Ana	Largely preyed upon by sandal roots.
14	Schleichera trijuga.	Puvandi	....
15	Dolichos sp ? ..	Kattu-thamattai ..	....
16	Pterolobium indicum.	....	....
17	Cryptolepis buchanani.	Palkodi	Sparingly attacked by sandal.
18	Webera corymbosa.	Veppura	Attacked by sandal pretty extensively.
19	Olea dioica ..	Rerumpungu ..	Extensively attacked by sandal.
20	Litsaea zeylanica ..	Thagari	....
21	Zizyphus oenoplia ..	Suri	Sparingly attacked, as there were only a few scars of haustoria.
22	Smilax scandens ..	Kodali kodi	....
23	Cudrania sp ..	Egadi	....
24	Jasminum sessiliflorum.	Kodi-malli	....
25	Elaeagnus umbellata	Sirum-kulleri	....
26	Flacourtia cataphracta.	....	....
27	Memecylon edule ..	Valicha	....
28	Eugenia jambolana	Navvey	....
29	Morinda umbellata	Sendikodi	Pretty extensively attacked by sandal roots.
30	Clematis gouriana ..	Ponrakodi	....
31	Ardisia humilis ..	Kollurumai	....
32	Celtis sp. ..	Peenjani	....

APPENDIX B —*concld.*

Serial number	Botanical name	Vernacular name	Remarks
33	Ehretia buxifolia ..	Korakku-vettilasi ..	....
34	Ligustrum neilgherrense.	Mani-pungan	Fairly largely attached by sandal roots.
35	Randia dumetorum	Markallan	....
36	Zizyphus rugosus ..	....	....
37	Ficus asperrima ..	Peperukkai	....
38	Asparagus racemosus	Thannir-muttan ..	....
39	A lauracious shrub with wavy leaves.	....	....
40	Gymnosporia montana.	Kattanji	Largely attached by sandal.
41	Premna tomentosa	Narumpinji	....
42	Ochna sp. ..	....	....
43	Tiliacora racemosa	Kattu-kodi	Largely attacked, probably by sandal roots.
44	Embelia viridiflora	Kakattan	....
45	Cocculus macrophyllus.	....	....
46	Dioscorea pentaphylla.	Mullankodi	....
47	Memecylon heyneanum	Kayila	....
48	Canthium didymum	Alumba	....
49	Strobilanthus sp. ..	Kurunju	Extensively attacked by sandal.
50	....	Paku pattai	....
51	Flacourtia sepiaria	....	Fairly attacked by sandal.
52	Atalantia monophylla.	Kurundu Katelimicham	Very largely attacked by sandal roots.
53	Dodonaea viscosa ..	Velari	....
54	Breynia rhamnoides	Sittuduvai	....
55	Hiptage madablota	....	....
56	Pleurostylia wightti	Pavalicha	....
57	Zizyphus xylopyrus	....	....

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MAP
OF THE
MYSORE STATE
SHOWING
SANDAL SPIKE AREAS
Scale of Miles
REFERENCE
App. Area in sq. mls.
SANDAL SPIKE SEVERE 500
" " SPORADIC 1600
S. CANARA
COORG
MALABAR
COIMBATORE
SALEM
NARCOT
MYSORE
HASSAN
BANGALORE
KOLAR
TIPTUR
TURVIKERE
BELUR
MUDGERE
SAKLESPUR
ALUR
CHANNARAYAPATNA
ARKALGUD
HOLE-NARSIPUR
KRISHNARAJPET
KUNIGAL
MAGADI
NELAMANGALA
HOSKOTE
MULBAGAL
BOWRINGPET
Talyhalpur
CLOSEPET
ANEKAL
KANKANHALLI
Kodihalli
MANDYA
SERINGAPATAM
MALVALLI
Sumdgur
T. NARSIPUR
YELWAL
HUNSUR
NANJANGUD
HEGGADDEVANKOTE
Kakankote
YELANDUR
CHAMRAJNAGAR
GUNDLUPET
YEDATORE

ATUR TALUK. SALEM DISTRICT

REFERENCE

- Reserve Forest Boundary
- Sandal Area
- Spiked "
- Reserve Land under Sec 4
- Bridle Path
- Foot Path
- Village Site
- " Boundary

MAP
SHOWING
SANDAL & SPIKED AREAS
ON THE
KOLLIMALAI HILLS
NAMAKKAL TALUK
TRICHINOPOLY DISTRICT

Scale of Miles